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# Mechanical Refrigeration.

PROCESSES AND APPARATUS

OF

# THE DE LA VERGNE REFRIGERATING MACHINE COMPANY

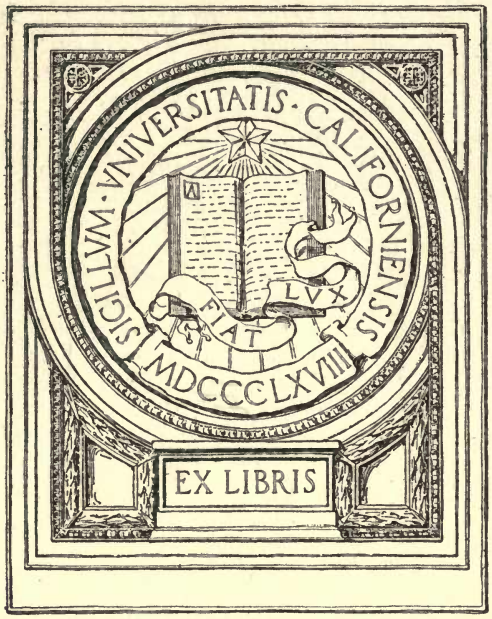
OF

NEW YORK.

1890.

A SATISFIED CUSTOMER IS THE BEST ADVERTISEMENT.

GIFT OF
Mrs. de Fremery



THE

# DE LA VERGNE REFRIGERATING MACHINE COMPANY

OF NEW YORK CITY.

Catalogue

Organized February 14, 1880.

OFFICE AND WORKS:

FOOT OF EAST 138TH STREET (PORT MORRIS),

NEW YORK.

THIRD EDITION.

JOHN C. DE LA VERGNE, President.
LOUIS E. DE LA VERGNE, Vice-President.
C. H. CONE, Secretary.

NEW YORK:
1890.

TP495
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1890

PRESS OF
JENKINS & McCOWAN,
224-228 CENTRE ST.

# ANHYDROUS LIQUID AMMONIA

FOR

# ICE MACHINES

AND

# REFRIGERATING APPARATUS

MANUFACTURED BY

## THE DE LA VERGNE REFRIGERATING MACHINE COMPANY.

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We guarantee all Gas Manufactured by us to be perfectly Anhydrous; a stock is kept constantly on hand, and shipments to customers are made in wrought-iron packages, hermetically sealed.

FACTORY: FOOT OF EAST 138TH STREET,
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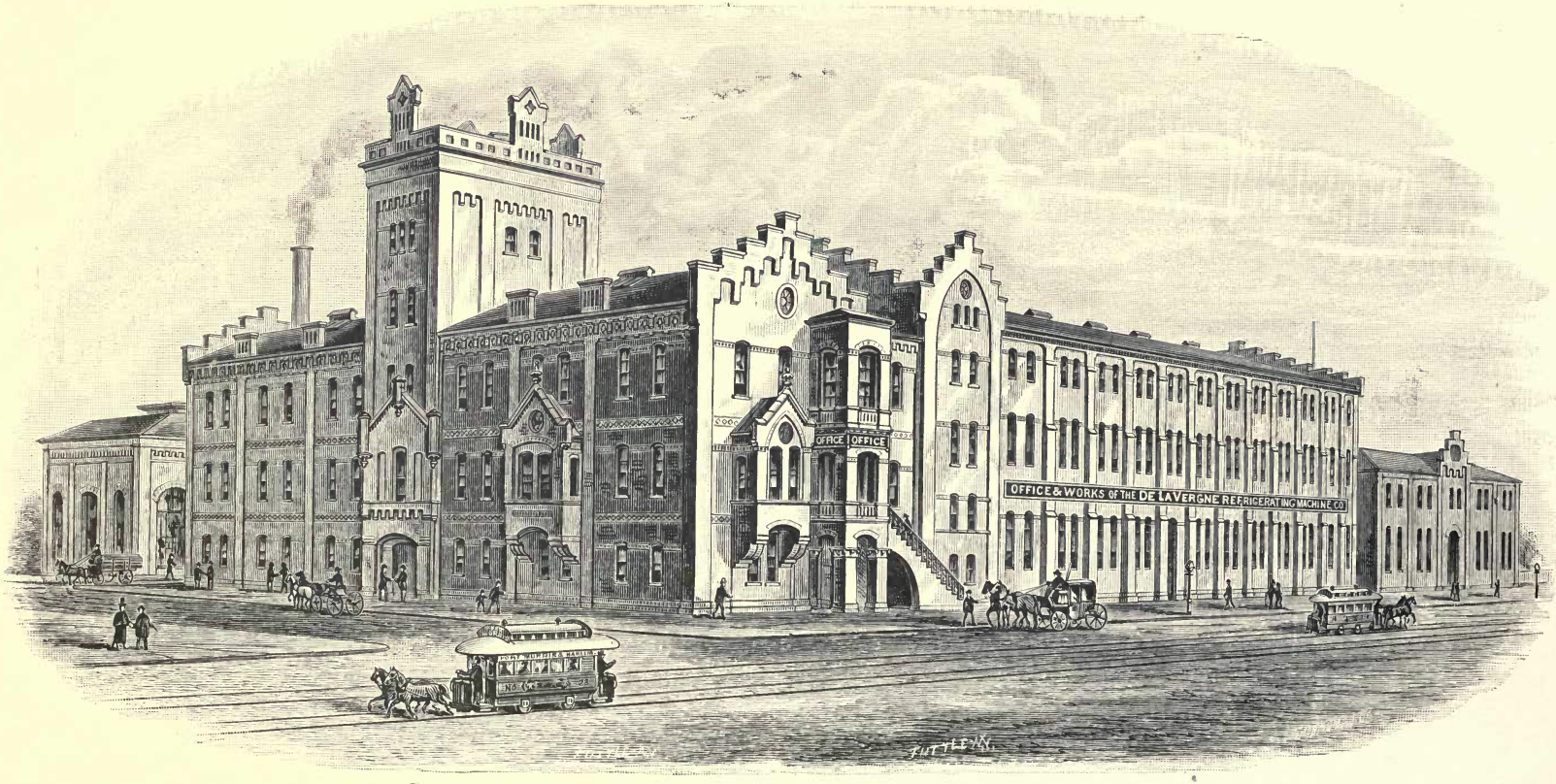


PLATE I.—Office and Works of the De La Vergne Refrigerating Machine Co.

# INTRODUCTION.

In presenting this third edition of our illustrated catalogue to the public interested in mechanical refrigeration and ice-making, we call particular attention to one great change we have introduced since the issue of our last edition. This is the double-acting compressor. While the fundamental principles of our machines and system, as far as they relate to the expansion and compression of the ammonia, have remained the same—and we may say, to-day, will remain the same in future—and while the general style and appearance of the machine has likewise undergone no change, yet we have for many years experimented on many different forms of double-acting compressors, which would be capable of handling the ammonia equally well on both sides of the piston in connection with our system of oil-circulation. The great advantage offered by a gas-pump which would do twice the work with hardly any increase in friction was something to be worked for. The result of our labors has been a double-acting compressor, which in every detail of its working is equal to our old single-acting compressor, does double the work, and saves one-eighth of the power to operate it over a single-acting compressor

of the same capacity. In addition to this advantage the cost of our machine is greatly reduced, and the space which the machine occupies is the same for a doubled capacity.

The condensers have been made considerably lower than in former years. By a large series of experiments we have found that the high condensers were only partly efficient in absorbing the heat from the gas, *i. e.*, only part of the pipes did actual cooling work, while the balance remained inactive. This has reduced the height of the condensers about nine feet, which is a gain in so far as the condenser-room thereby needs to be so much less in height.

The engine-room connections have been simplified by abolishing the low-pressure oil tank. The latter has been found superfluous when the oil is injected under pressure; which gives us a slight advantage over our old system of charging the oil into the compressor under the suction or back-pressure of the machine.

The pipe system, with its cocks and fittings, has undergone no change, but by adding quite a number of special patterns we are enabled to construct the pipe system in a more perfect and pleasing manner.

The construction of the pressure-tank with baffle plates, which we use on all our larger machines, has made the separation of the oil so perfect that only traces of it are carried over into the separating-tank.

As in our former editions, we propose to submit to the public a concise and clear presentation of the different processes followed in artificial refrigeration, of the

difficulties hitherto encountered in making these processes successful, and of the means we have employed to overcome these difficulties, to aid the intending purchaser of refrigerating machinery in arriving at a just and fair conception of the advantages and disadvantages of the various systems now in the market.

It may be more satisfactory to those unfamiliar with the subject if we first submit a brief statement of the principles and processes involved in cold-producing machines.

The processes are exceedingly simple, and substantially consist of a cycle, or round, of three operations, following each other in rotation, and which are practically the same in almost all the refrigerating machines now in use.

THE DE LA VERGNE REFRIGERATING MACHINE CO.

NEW YORK, January, 1890.

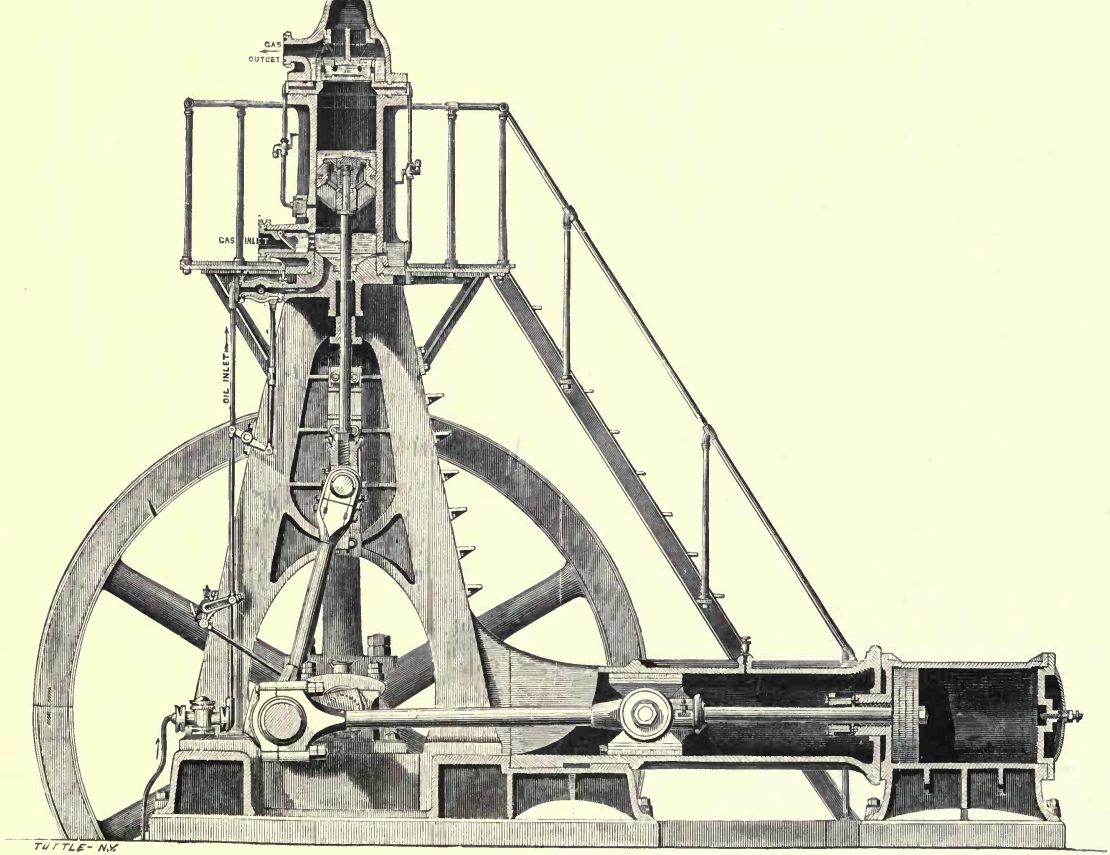


PLATE 2.—Sectional View of Single-Acting Machine.

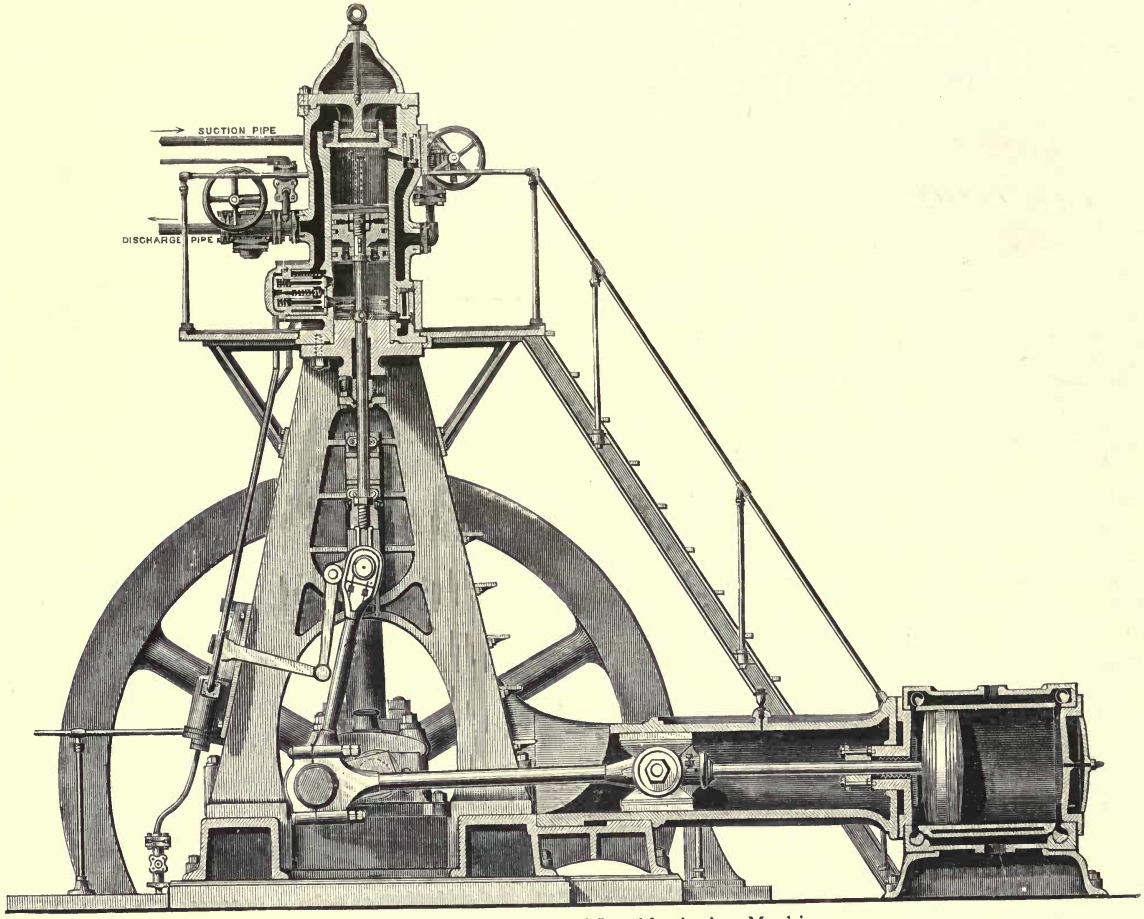


PLATE 3.—Sectional View of Double-Acting Machine.

# THEORY OF MECHANICAL REFRIGERATION.

HAVING first selected the refrigerating or heat-absorbing agent to be used, such as ammonia, ether, sulphurous oxide, etc., this agent is charged into the machine, and afterward passed through the round of the three operations just alluded to, which are as follows :

1. *Compression.*

The agent in gaseous form is compressed to a pressure, varying in the case of ammonia from 125 to 175 lbs. per square inch, and depending upon the temperature of the condensing water used, either mechanically or otherwise, in order to prepare it for the second operation. During the compression, heat is developed in proportion to the amount of pressure exerted upon the gas, or to the relative volume to which it has been reduced. Expressed popularly, heat is squeezed out of the gas, and can then be carried away by the condensing water.

2. *Condensation.*

The heat developed in the above operation is withdrawn from the compressed gas by forcing it through coils of pipe while said coils are in contact with cold

water; the heat being transferred to the water surrounding the coils. When this point is reached the gas is ready to assume the liquid condition, and in so doing it gives off additional heat to the surrounding water, as explained more fully hereafter.

3. *Expansion.*

The liquefied gas thus obtained is allowed to enter coils of pipe so placed that the substance to be cooled (air, water, brine, beer, etc.) can be brought into contact with them, the pressure in the interior of these coils being maintained at a lower point than that required for retaining the gas in the liquid state. The liquefied gas, upon entering said coils, re-expands, and extracts from the pipes and the substances surrounding the pipes the same quantity of heat that was previously given up by the gas to the water used during the period of condensation and liquefaction. The gas having performed in this last operation its refrigerating work, is now ready to repeat the same cycle of operations.

Modifications of the above, and several auxiliary processes, have been introduced in the various machines of different inventors; still the general principles remain the same, the round of operations above cited being essential to form a complete cycle.

From the above, it will be readily understood that a refrigerating machine consists of three series of parts, each corresponding to one of the above operations:

1st. *A compression side,* in which the gas is compressed, either mechanically or otherwise, as will be more fully explained in describing absorption-machines.

2d. *A condensing side*, generally consisting of coils of pipe, in which the compressed gas circulates, parts with its heat, and liquefies; and

3d. *An expansion side*, consisting also of coils of pipe, in which the gas re-expands and performs the refrigerating work.

In order to render the operation continuous, these three sides or parts are connected together, the gas passing through them in the order named.

The gas is drawn through the expansion coils by the pumps at a pressure varying from 10 to 30 pounds above that of the atmosphere, where ammonia is in use, and is then forced into the condensers, where a pressure of 125 to 175 pounds per square inch usually exists; here liquefaction takes place, and the resulting liquefied gas is allowed to flow to a stop-cock having a minute opening, which separates the compression from the expansion side of the plant.

The expansion side consists of coils of pipe similar to those of the condensing side, but used for the reverse operation, which is the absorption of heat by the liquefied gas instead of the expulsion of heat from it, as in the former operation.

Heat is conducted through the expansion or cooling coils to, and is absorbed by, the expanding liquefied gas within such coils, for the reason that they are connected to the suction or low-pressure side of the apparatus from which the pumps are continually drawing the gas and thereby reducing the pressure in said coils, as already stated, to a pressure of 10 or 30 pounds above the atmos-

phere; it being kept in mind that liquefied ammonia in again assuming a gaseous condition, at atmospheric pressure and a temperature of 60° Fahr., expands a thousand times and has the power or capacity of reabsorbing, upon its expansion, a quantity of heat equal in amount to that originally held and discharged from it during liquefaction. The liquefied gas entering these coils through the minute opening of the stop-cock above referred to is suddenly relieved of a pressure of 125 to 175 pounds, the amount requisite to maintain it in a liquid condition, when it begins to boil, and in so doing passes into the gaseous state. To do this it must have heat, which can be supplied only from the substances surrounding the pipes, such as air, brine, water, wort, etc. As a natural result the surrounding substances are reduced in temperature, or cooled; the quantity of heat taken up by the gas being the same as that which was expelled from it during its liquefaction in the condensers. It is apparent, from the foregoing, that if the expansion coils are placed in an insulated room, that room will be refrigerated; also, if brine or wort is brought in contact with the surface of the coils, they also will be reduced in temperature; and that brine so cooled can be used to refrigerate an insulated room by simply forcing it to circulate through pipes or gutters suspended in the same.

Either of the above methods can be applied to the refrigeration of breweries, packing-houses, etc., and for the manufacture of ice, the same gas being used over and over again to perform the same cycle of operations.

As said before, various modifications of the above,

as well as auxiliary processes, have been introduced by patentees and builders in their several machines; but the principles already described are the same in all, the difference being in their application.

## VARIOUS SYSTEMS AND REFRIGERATING AGENTS EMPLOYED.

As far back as the year 1550 Blasius Villafranca, a Roman physician, produced an artificial reduction of temperature by dissolving saltpetre in water; and in 1607 the first "frigorific mixture" was discovered by Latinus Tancredus, who, by combining snow with saltpetre, produced very low temperatures. A well-known frigorific mixture is used the world over to-day in the manufacture of ice-cream, *viz.*, pounded ice and common salt, which produces a temperature of ten degrees Fahrenheit. Other mixtures were later on discovered, some of them using ice or snow as an auxiliary, others using merely a combination of chemicals, such as sulphuric acid, muriatic acid, chloride of sodium (common salt), chloride of calcium, nitrate of ammonia, etc.

In 1824 Vallance patented an ice-machine, in which a current of dry rarefied air was circulated over shallow pans containing water. The air absorbed the vapors of the water, and the heat necessary to produce these vapors was taken from the main body of the water and froze it. The air thus laden with moisture was passed

over concentrated sulphuric acid, which absorbed the watery vapors and made the air fit again for taking up new vapors from the water to be frozen. Thus a continuous process was established.

In 1834 Perkins constructed a machine in which cold was produced by the evaporation of ether The ether was vaporized in a cylindrical vessel containing tubes by reducing the pressure on it through the sucking action of a pump, which on its return stroke compressed the ether into another vessel, cooled by water, thus restoring the ether and making it fit to be used over again. Here the compression system makes its first appearance.

But it was not till the year 1855 that results were produced which could be called practical. Prof. Twining, of New Haven, Connecticut, had been experimenting with sulphuric ether between the years 1848 and 1850, and obtained his first patent in England in 1850. The American patent was issued to him in 1853, and in 1855 he operated a machine in Cleveland, Ohio, which was intended to produce 2,000 pounds of ice in 24 hours. It did actually produce over 1,600 pounds under disadvantages, and was operated, off and on, from 1855 to 1857. In this machine the "compression" system of to-day is completely represented, and Twining deserves the credit of not only being the inventor of this system, but of also having carried it out in practice. Yet the inflammability of ether; the high vacuum, which had to be carried on the evaporation side of the pump, and which allowed air to enter into the apparatus; the difficulty of proper

lubrication—all presented great obstacles against the reliable and permanent operation of the machine; so that inventors turned their attention to other substances better adapted to the purpose, among which we may mention Ammonia, Sulphurous Oxide, Carbonic Acid, Methylic Ether, Nitrous Oxide, Methylamine and Chymogene.

To discuss the relative advantages and objectionable features of these various substances would occupy a great deal of space and be of little interest to the general reader; suffice it to say that "Anhydrous Ammonia," or ammoniacal gas entirely deprived of moisture, answers the purposes of artificial refrigeration better than any other known substance. Its boiling-point—27° Fahrenheit below zero at the pressure of the atmosphere—ensures low temperatures without resorting to very low pressures on the evaporation or expansion side of the machine, and thereby large pumps are avoided, the gas still producing sufficiently low temperatures at a boiling pressure of 15 to 25 pounds per square inch. At this pressure the gas weighs more per cubic foot than at a lower pressure, and one charge of a given pump will produce more cold than if the gas were taken in at a lower pressure, since it is *weight* of gas circulated, and not *volume*, which gives us a standard of cold-production.

The latent heat of ammonia is higher than that of any other known agent hitherto used for the production of cold, and a smaller quantity is therefore needed to produce a certain cooling effect. Its great stability, its non-inflammability and non-explosiveness, allow it to be

used in any kind of machine for a great length of time; and while it attacks copper and brass, it has not, even if mixed with water, the slightest effect upon iron or steel, so that the machinery and piping, which convey and circulate it, are never in the least degree corroded.

It seems in the highest degree natural, therefore, that after many years of experience and investigation by scientific men it should have attained the position in mechanical refrigeration which it occupies now, that of being the agent *par excellence* for purposes of cooling.

## TWINING'S COMPRESSION MACHINE.

To return, however, to the early days of Twining. This original and advanced scientist discovered, during his experiments with ether from 1848 to 1850, that one pound of ether, by its evaporation, was adequate to produce 1.2 pounds of ice from water of 32° Fahr., besides cooling down the ether 28°. In his Cleveland machine he had a double-acting vacuum and compression pump of 8½ inches diameter and 18 inches stroke, making 90 revolutions per minute. He compressed the vapors into a tubular condenser or "restorer," in which, under the cooling action of water, the ether was liquefied. From the restorer the liquid entered a "cistern" through a pipe and cock, to be there re-evaporated through the sucking action of the pump, thus cooling the cistern to below the freezing-point of water. The cistern was so constructed that it formed a system of cells open at the

top, into which iron moulds were placed, also open at the top, and surrounded by a non-congealable liquid, so that water contained in the moulds was frozen from the outside. After all the water was frozen solid, the mould was lifted from its cell and the ice block melted out. This is exactly what we do to-day. Twining also found that at a comparatively high temperature the ice would be perfectly transparent with the exception of a small porous core, but that with low temperatures it would be opaque. In carrying on the process of cooling after all the ice had been formed, he obtained a final temperature of 26° Fahr. below zero with an absolute evaporating pressure of 2.7 inches of mercury.

## GORRIE'S COMPRESSED-AIR MACHINE.

In 1850 Dr. John Gorrie, of New Orleans, at the instance of some capitalists, conducted a series of experiments, the object of which was the generation of cold by the expansion of atmospheric air. It was known that air was heated during compression, and that it would cool down again during expansion; and since this heating amounted to many hundred degrees during compression up to four or five atmospheres, the inference was that the cooling effect would be the same if the compressed air were allowed to expand after it had cooled down to the surrounding temperature of the atmosphere, or after it had been cooled down by water. At that time, however, the laws of thermo-dynamics

were not yet thoroughly understood, and although Dr. I. R. Mayer, of Heilbronn, had as far back as 1842 pronounced the fundamental law of this branch of science, that heat and mechanical duty are equivalent, and that the one could be converted into the other,* yet the whole problem was not sufficiently developed. While Gorrie's experiments at that time had a certain *practical* value, the discoveries of the twenty years following deprived them of much *scientific* worth.

The fact, however, that cold *could* be produced without any chemicals, simply by the compression of the air that surrounds us everywhere, offered such a strong temptation to inventors that the subject was afterward taken up again by Giffard, of France, Windhausen, of Germany, Bell-Coleman, Haslam, and Lightfoot, of England, and Allen, of the United States. The laws and formulæ of the mechanical theory of heat had proved that, even under the most favorable assumptions, the power necessary for the compression of a certain quantity of air in order to produce a certain amount of cold was far in excess of that which was needed if a liquefiable gas or a volatile liquid was used for the same purpose.

To establish a basis for the measurements of heat, physicists have long ago agreed to call the quantity of heat which is necessary to heat one pound of water one degree Fahr. a "unit of heat" or "thermal unit." Thus, to heat one pound of water 50° requires 50 thermal units, or to heat 10 pounds of water 20° requires $10 \times 20 = 200$

* "Annalen von Woehler und Liebig," May, 1842.

units. All bodies, however, do not require the same amount of heat per pound in order to raise their temperature 1°. For instance, to heat one pound of iron 1° requires only $\frac{11}{100}$ heat units; one pound of lead, only $\frac{3}{100}$; one pound of olive oil, $\frac{3}{10}$; one pound of ice, $\frac{5}{10}$, etc. This peculiar quality of different bodies needing different quantities of heat to raise one pound of them 1° in temperature is called their "capacity for heat," or their "specific heat." In examining air, Regnault has found that its specific heat is only about $\frac{1}{4}$ (0.238). One cubic foot of air weighs at atmospheric pressure about $\frac{1}{13}$ pound, and so it is apparent that it requires only one thermal unit to heat $13 \times 4 = 52$ cubic feet of air 1° Fahr. Water weighs 63 pounds per cubic foot, and it needs 63 units to heat one cubic foot of water 1° Fahr. If we, therefore, compare air and water we find that it takes only the $\frac{1}{52 \times 63} = \frac{1}{3276}$ part of heat to raise one cubic foot of air 1° that it takes to accomplish this with one cubic foot of water. It would lead us too far into scientific considerations if we attempted to follow this matter any further; but so much will appear, that the capacity of air for heat is extremely small. The necessary consequence is, that to utilize this body for the generation of cold enormous quantities of it have to be handled. The compressing-pumps of air machines are very large, the friction to operate them is great, and the loss by leakage around the piston becomes considerable in the course of time.

Apart from these facts, the greatest obstacle to the economical use of air for cooling purposes is the circum-

stance that air is a permanent gas, *i. e.*, it cannot be liquefied; at least, not under moderate pressures and temperatures such as we are compelled to deal with in the mechanical arts. If we compress air, we heat it to say 400 or 500°, and if we then cool it down to 80° this difference in temperature represents all the heat that we can take out of it so as to enable it to absorb heat again during its re-expansion. If, however, we compress a liquefiable gas, such as ammonia, we likewise heat it; but in cooling it down to its temperature of liquefaction it does not retain its gaseous condition, but becomes a liquid. In doing so, it parts with a great amount of heat which was necessary to maintain it as a gas. We are thus enabled to carry away much more heat with the cooling water, which all refrigerating machines require, which heat must be taken up again when the liquefied gas re-expands. One pound of ammonia, in thus liquefying, will part with about 560 thermal units, which will be reabsorbed when it re-enters the condition of a gas. This heat is called "latent heat," because it cannot be discovered by the thermometer.

We have mentioned before that the specific heat of all bodies is not the same, and such is also the case with all bodies in relation to their latent heat. To be well adapted for purposes of refrigeration, the agent employed should have a high degree of latent heat, so that small quantities of it only are needed to produce a certain effect. If we now reflect on the reasons stated in connection with the question just discussed in its bearing on refrigerating machines using air, we will

more fully understand why such large pumps are needed.

In 1851 Gorrie, however, obtained a patent on an air machine in the United States, and it contained valuable points, such as, for instance, the internal cooling of the compressor by the injection of cold water. In the face of the progress made during the last ten or twelve years in the compression of liquefiable gases, the air machines have been compelled to retire to the background in the art of mechanical refrigeration. Their only use, it may be asserted, is on shipboard for the purpose of transportation of perishable food. Here machines of comparatively small capacities only are needed, and the large coal consumption—it is from eight to ten times that of good ammonia-compression machines—does not play so important a part as on land, where machines of such large sizes are now employed that their coal consumption would be fifty tons a day if worked on the compressed air principle, while our machines of the same size actually use only five to six tons. Nevertheless, ammonia machines are fast replacing the air machines, even on steamships, on account of their perfected construction and their economy in running.

## CARRÉ'S ABSORPTION MACHINE.

During a number of years no notable progress was made in the art of refrigeration, and no new ideas were advanced. In 1858, however, Ferdinand Carré, of France,

proposed an entirely new and original plan of liquefying ammonia, using therefor the aqueous solution of this gas, 25 parts of ammonia in 75 parts of water.

By his system, which is called the "absorption system," in consequence of the terminal operation, the aqueous solution of ammonia is heated in a boiler or still, until the ammonia is driven off in the form of a gas mixed with aqueous vapor (steam), the proportions being about 90 per cent. of ammonia gas and 10 per cent. of aqueous vapor; the resulting vapor is then carried through the three operations of the cycle already described.

1. The gas is compressed by the pressure resulting from its distillation.

2. It is cooled and liquefied in a coil of pipe surrounded by cold water.

3. It is allowed to re-expand to a gaseous state in coils surrounded by the substance to be cooled, in the same manner as heretofore described on pages 9, 10 and 11. The resulting gas, having done its work of refrigeration, is then led from these coils through a pipe to another coil of pipe, and from this coil to still another coil called the absorber, placed outside of the room or substance cooled.

In this coil (the absorber) the gas is brought in direct contact with the water (mother liquid), from which it was originally expelled by heating; said water having in the meantime been moved or circulated out of the still above referred to, through coils of pipe over which cold water is constantly running. From these coils of pipe it passes

on to the before-mentioned absorber, over which water is also constantly running. The water (mother liquid) having thus been cooled, rapidly absorbs the gas, forming again a strong solution of ammonia. This solution being returned to the boiler by means of a pump enables the gas to go through the same cycle of operations. The machinery required to perform these operations is exceedingly simple, and comparatively cheap in construction; but it is very wasteful of coal and cooling water, and its efficiency is greatly diminished by the steam generated with the gas in the boiler or still. The coal consumed in generating this steam is worse than wasted; the steam condenses with the gas in the condensing coils and passes to the expanding coils, where it accumulates in considerable quantity and retains a large percentage of the gas in solution.

Now, bearing in mind the fact that water at a temperature of 60 degrees Fahrenheit will absorb more than 700 times its volume of ammoniacal gas at the pressure of the atmosphere, it must be perfectly evident that the existence of this water in the expansion coils is a serious drawback, independent of the cost of fuel lost in placing it there, as it absorbs and renders inoperative large quantities of the gas, which have been generated or driven out from the mother liquid at no inconsiderable cost in fuel. There is a constant accumulation of such water, and to such an extent, in many of the machines on the market, that their action is intermittent, and it frequently becomes necessary to stop running, reverse their action, and, by pressure, blow the accumu-

lated water into the absorber; this is a very objectionable feature in the system, to say nothing of the cost of pumping the excessive supply of water used for cooling, and in many places the additional cost of procuring this extra supply.

Another evil attending this system is that a large amount of the heat expended in vaporizing the ammonia in the boiler is lost, because of the necessity of cooling the boiled liquor before it can be used in the absorber, and a large proportion of the excess of water employed in this system is used for cooling this boiled liquor before and during absorption. Both theoretically and practically about 60 per cent. more fuel is required to expel the ammonia from its aqueous solution, to compress and liquefy it, and to return it reabsorbed in the boiled liquor to the boiler, than is found necessary in the mechanical compression of the anhydrous gas.

Not only do absorption machines consume much more fuel, but they require from two and one-half to three times as much cooling water as the compression machines. A number of delicate adjustments are required in order to regulate the various operations, such as the rate of boiling in the stills, the flow of weak boiled liquor to reabsorb the evaporated gas, etc.

These adjustments have to be altered to meet the varying requirements of the establishment being refrigerated, and are apt to give great trouble. Such machines work very irregularly, and usually fail when most wanted, thus entailing heavy loss and disappointment on their owners.

It must be admitted that Carré's machine proved its inventor to be a man of great originality of thought; and the seeming simplicity of the apparatus, as, for example, the absence of a steam-engine and compressors, was a feature which in the beginning recommended it very strongly to users of cold and ice. The before-mentioned defects, however, soon made themselves felt, and in spite of the great efforts exerted to overcome them, inventors and engineers have, up to this day, failed to accomplish what to all appearances seems to be a physical impossibility.

## MECHANICAL COMPRESSION.

To remedy the above condition of affairs, inventors turned their attention again to the mechanical compression of anhydrous gas, which is accomplished by means of powerful vacuum and compression pumps; but here such varied mechanical difficulties were encountered that many, not seeing their way clear to overcome them, have hesitatingly returned to, and are still struggling with, the absorption system. The mechanical difficulties encountered in pumping a gas of the extreme tenuity of ammonia may be stated as threefold in number, and are as follows:

1. *The Imperfect Discharge of the Gas from the Pump.*

This it was found impossible to overcome until we perfected our present compressor. As a clearance must

necessarily be left between the piston and the cylinder-head, only a portion of the compressed gas was expelled at each stroke; that remaining re-expanded with the reverse motion of the piston, produced a pressure against the incoming charge of gas, and resulted in a loss of power and efficiency.

2. *Leaky Stuffing-Boxes, Pistons, and Valves.*

In ordinary compressors the motion of the piston and rod, at each alternate stroke, would either introduce air into the pump, providing the internal pressure was less than that of the atmosphere, or draw out and waste a volume of the refrigerating gas, and it was impossible to pack a pump piston and gland sufficiently tight to prevent these difficulties. In some cases where the attempt was made, the power required to overcome the friction of the stuffing-box thus tightened was found more than sufficient to do the entire work of compression. Again, working against constant pressures of 125 to 150 lbs. necessitated the use of a tight piston, the least wear causing considerable leakage of gas past the piston into the adjoining pump chamber. Similar difficulties were also encountered with the valves, causing the gas to re-enter the pump past the discharge-valves, or to be returned to the suction side past its corresponding valves. It will be well to mention here that, to obviate the leaky stuffing-box, some makers have resorted to the device of ejecting a stream of water against the piston-rod and stuffing box, ostensibly to cool the rod, but in reality to absorb the gas leaking

past the gland, thus rendering a great source of loss inapparent, which loss, in connection with a leaky piston and valves, materially reduces the efficiency of the pump.

3. *The Heat of Compression.*

The mechanical energy which the compressor piston exerts upon the gas is converted into heat, which by expanding a tight packing of the piston causes friction; while on the other hand a loose packing of the piston, or its eventual wear, allows the gas to slip past.

The heat of compression expands the gas during compression, thereby increasing its volume, which necessitates an opening of the discharge valve prior to the time that it would open were the gas cooled during compression.

The work spent in effecting this prior discharge of the increased volume of gas is work lost.

To avoid these losses, and to obtain a higher efficiency in compressors other than ours, the device is resorted to of flooding the external portion of the cylinder with water, and also of circulating a stream of water through the piston and piston-rod; but in such cases the thickness of metal required in the construction of the pumps and piston is so great, that the cooling effect is only an approach to that which would effectually prevent such losses. In fact, this cooling only benefits the walls of the compressor, while the gas itself is practically not at all reduced in temperature.

The mechanical difficulties enumerated and described were of such a serious nature that, until we perfected our present compressor, gas pumps or compressors had attained an efficiency of only 50 to 70 per cent. of their theoretical duty. They wore rapidly, requiring frequent reboring, repacking, and repairs, and were very defective, being excessive consumers of fuel, and losing an enormous quantity of expensive gas; and to such an extent as to make them too expensive to be practical, even though the first cost of the apparatus was relatively low in price.

## OUR PATENTED SYSTEM.

To make mechanical refrigeration a success, it is essential—1st, to discharge the entire volume of the gas entering the compressors; 2d, to prevent all leakage past the stuffing-box, piston, and valves; and 3d, to extract the heat from the gas during compression. All this we accomplish by a simple device, one for injecting into the compressor, at each stroke, a certain quantity of lubricating liquid, which effectually seals the stuffing-box, piston, and valves, fills all clearances, and takes up the heat developed during compression.

# OUR SINGLE-ACTING COMPRESSOR.

THE compressor is erected vertically, and the cylinder is a little longer than the stroke, thus providing a chamber at the lower or stuffing-box end, which is always filled with the lubricating liquid, thereby completely and permanently sealing the stuffing-box or piston gland; and upon the downward stroke of the valved piston more lubricating liquid is introduced into the chamber by a plunger-pump attached to the cross-head, or by some other device, which liquid is forced through the valve, and covers the upper surface of the piston. On the reverse or upward stroke, the gas is first expelled; the lubricating liquid then follows and fills all clearances, entirely covering the discharge valve, and accomplishing the following objects:

1. It ensures the expulsion of the entire volume of gas taken in at each stroke of the pump.

2. It effectually seals the suction valve, the piston, the stuffing-box, the piston-valve, and the discharge valve—preventing all leakage.

3. It obviates the necessity of packing the stuffing-box tightly, and thoroughly lubricates the piston and piston-rod at every portion of the stroke, thus reducing the friction to a minimum.

4. It takes up a considerable amount of the heat developed in the gas during compression, thereby economizing largely the power required for compression.

The practical result obtained by the use of the lubricating liquid resolves itself into the consumption of less fuel, less ammonia, and less water by our machines than by those of other builders.

The following plate and description will explain more clearly the construction of our single-acting compressor:

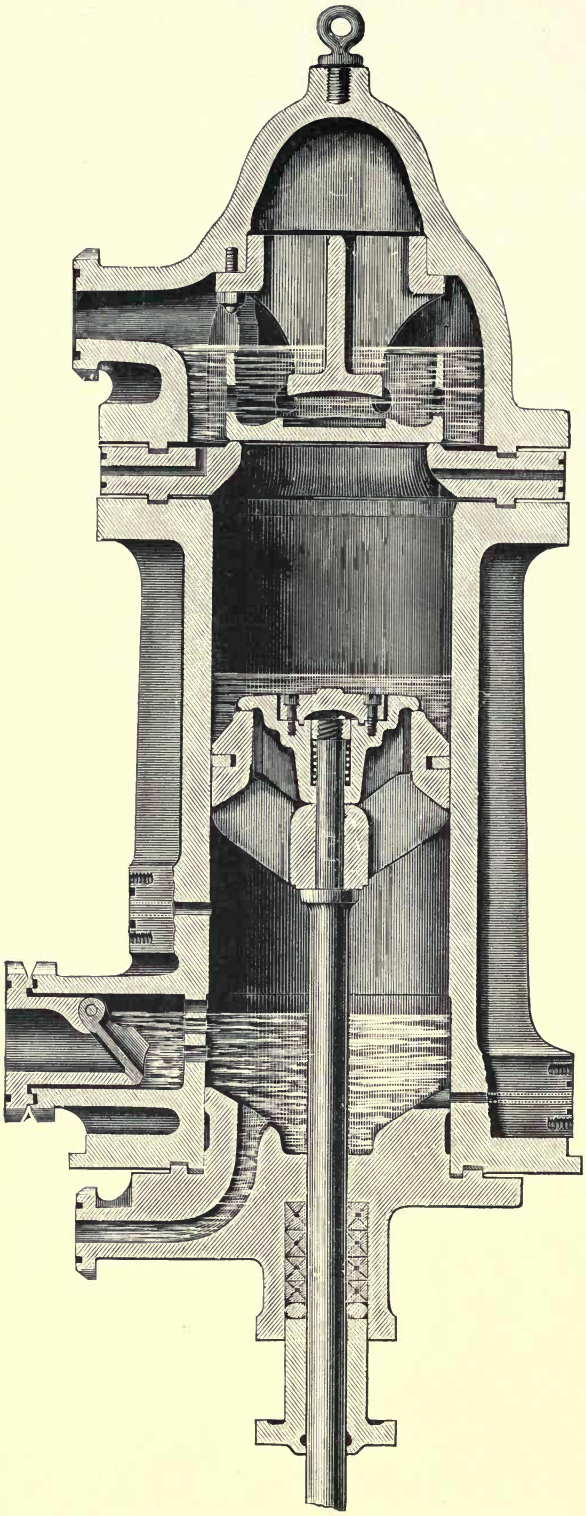

PLATE 4.—Sectional View of Single-Acting Compressor.

Plate 4 is a vertical compressor, having a valved piston and a valved diaphragm. The gas enters the pump from the return mains through the large opening on the left-hand side near the bottom of the pump, on the up stroke of the piston. On the return stroke, the valve in the large gas inlet closes, and the gas in the cylinder passes to the upper side of the piston through the valve in the piston, which opens as soon as the valve in the gas inlet closes.

The lubricant for cooling the pump and sealing its valves and piston-rod is injected through the small aperture at the bottom and left side of the pump *during the return stroke of the piston;* therefore it will be observed that the cylinder is fully charged with gas before the introduction of the lubricant, and that the lubricant does not occupy any space to the exclusion of gas.

As the piston descends it becomes submerged in the lubricant collected in the bottom of the cylinder, and a small quantity of it passes through the open valve to the upper side of the piston, and effectually seals the piston and prevents a slippage of gas past it during the act of compression or during its upward stroke.

A sufficient body of the lubricant is introduced to the upper side of the piston to enable us to drive out all the gas, and, with it, a portion of the lubricant which passes through the diaphragm valve and which seals said valve upon the return of the piston.

The piston-rod is continually liquid-sealed by the remaining lubricant surrounding it.

The gas is discharged through the outlet on the left-hand side at the top of the pump.

It will be observed that the piston is at all times thoroughly lubricated, and the valves holding the gas are sealed under a pressure greater than that of the atmosphere, giving no opportunity for wear or a slippage of gas past the piston or through the stuffing-box, consequently we are enabled to pump a greater percentage of gas with less friction and less cost than any of our competitors.

## OUR DOUBLE-ACTING COMPRESSOR.

For a number of years we have been experimenting to solve the problem of constructing a double-acting compressor which would handle the gas in connection with our system of oil circulation as well on the up *and* down stroke as the single-acting compressor does on the up stroke. It is apparent that a double-acting pump is more advantageous—providing it is well constructed—because it handles double the amount of gas with every revolution of the crank-shaft that a single-acting compressor does, which has the same diameter and the same stroke. The moving parts, such as cross-head, piston, piston-rod, and connecting-rod being the same for either a single or a double acting compressor, the *friction will be the same for all these parts, while double the work is being effected.* To overcome friction means power expended

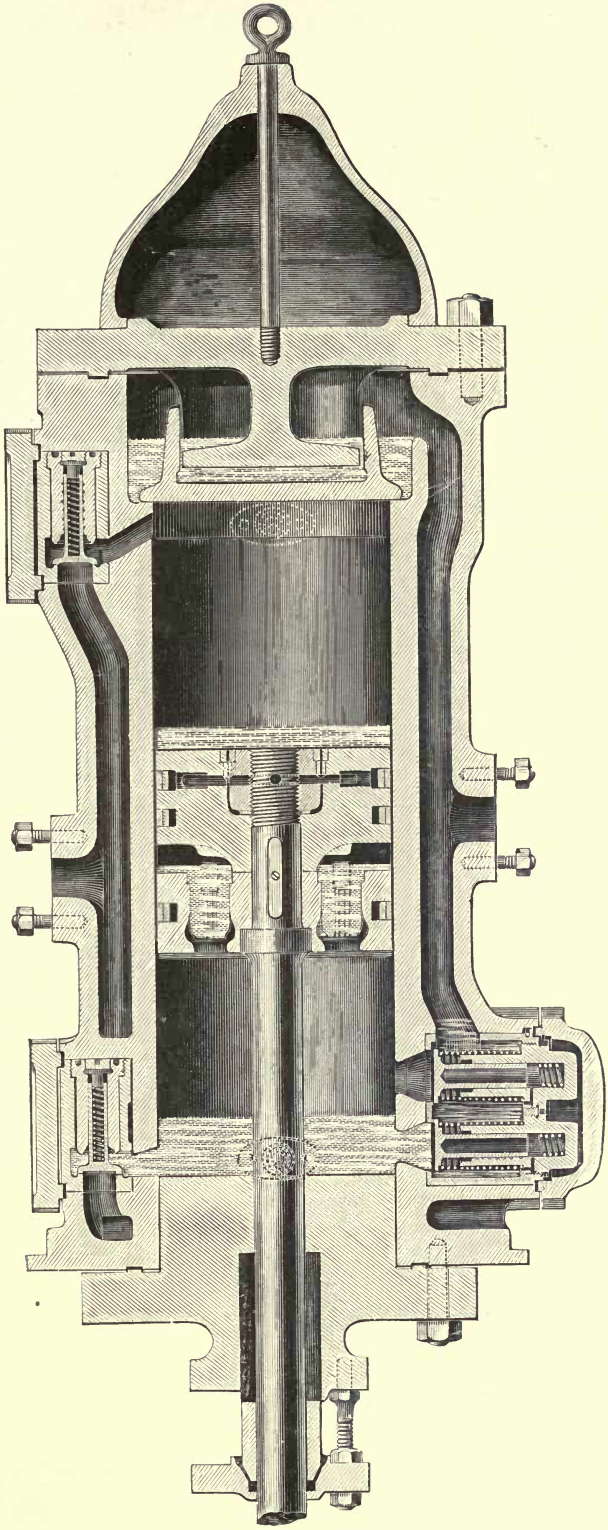

PLATE 5.—Sectional View of Double-Acting Compressor.

—*power wasted*—and in our case, viz., in a machine with two gas-compressors it means a saving of one eighth of the whole power used for compressing the gas. Another advantage is the cheapening of the machine through the fact that one double-acting compressor will do the work of two single-acting ones of the same size.

In attempting the construction of a double-acting compressor the oil-circulation proved a serious drawback to the proper discharge of the gas on the lower side of the piston, and still we could and would not give it up, because this would have meant an inferior pump. In the ordinary form of double-acting compressors the discharge-valves at the lower end are placed either on the side or in the lower head. In either case the oil is discharged on the down stroke *before* all the gas has left the pump—and this is wrong. The oil must be discharged *after* all the gas is gone, because otherwise re-expansion takes place, and this means loss of efficiency of the pump. We have avoided this difficulty in the following manner :

At the lower end of the compressor, Plate 5, there are two discharge-valves placed on the side—one above the other. On the down stroke either of the valves or both may open until the piston covers the upper one, when only the lower one is open to the condenser. In the further course of the piston and as soon as the lower valve is also closed, the upper one is in communication with an annular chamber contained in the piston. This chamber has valves in its bottom, which open into it as soon as all other outlets from the lower side of the pis-

ton are closed (they open a little harder than the discharge-valves on the side), and now the gas will all go out through the piston; and after the gas the oil will follow, thus permitting no gas to remain on the lower side after the completion of the down stroke. It will be seen that in this manner the very important oil-system of our machine is retained, and that the lower side of the pump works as well as the upper, while the oil effectually seals the stuffing-box in spite of the higher pressure on it at the end of the down stroke.

The machines with this style of compressor have been in operation, some of them, nearly two years, have all worked to our utmost satisfaction, and we are now recommending them as superior to the single-acting machines on account of the saving in power and greater cheapness.

A patent on this compressor has been granted to Mr. Louis Block, the chief-engineer of our company.

## EXPLANATION OF DIAGRAMS.

THE diagram represented in Fig. 2 was taken from one of our 14 x 28 gas compressors working at 150 pounds direct pressure, 27 pounds back pressure, and thirty-six revolutions a minute. The actual power indicated by this card is 48 H.-P.

The horse-power measured to the adiabatic curve equals 53.6 H.-P.

The horse-power economized in using the sealing

and lubricating liquid will therefore be 5.6 H.-P for each compressor. The number of compressors to each machine being two, the actual power saved will be 11.2 H.-P., and the efficiency of the compressor 99.6 per cent. of its theoretical efficiency.

The line *a* represents the adiabatic curve, the line *b* the isothermic curve, of this diagram.

Figs. 3 and 4 were taken from the steam cylinder actuating the 14 x 28 compressors at the time Fig. 2 was taken. The steam pressure in the boiler was 68 pounds. The initial pressure on card shows 65 pounds. The mean effective pressure of diagrams equals 32.4 lbs.

The horse-power developed was 63 H.-P.

The close approach of the expansion line of these diagrams to the theoretical curve shows the superior action of our cut-off valve, and its corresponding economy in steam.

The diagram shown by Fig. 5 was taken from a compressor not using the cooling, sealing, and lubricating liquid, and working with a direct pressure of 157 lbs., and a back pressure of 20 pounds.

The horse-power indicated by card is equal to 44 H.-P.

The compression curve of this diagram should approach the adiabatic curve *a*, but it actually drops close to the isothermic curve *b*, showing a leakage past the piston of 15.2 per cent. of the gas being compressed; and a loss of 7.4 per cent., as shown by the curved line *c*, caused by the re-expansion of the gas filling the clearance between the piston and compressor head. The

total loss, therefore, by not injecting the cooling and sealing liquid would represent 22.6 per cent.

The efficiency of the compressor in this instance would represent but 77 per cent. of the efficiency shown in Fig. 2, as a result of not using the sealing and lubricating liquid.

The diagram, Fig. 6, was taken from a 12 x 24 compressor for the purpose of showing the efficiency of the sealing and lubricating liquid working between extreme limits of pressure. The direct pressure in this case was 194 lbs.; the back pressure 9 lbs. The actual horse-power indicated by card equals 30 H.-P.

The horse-power measured to adiabatic curve equals 36.5 H.-P. The power economized by each compressor equals 6.5 H.-P.

The efficiency of the compressor in ejecting the entire volume of gas taken in at the suction side is clearly represented in the straight line *c*, which shows an efficiency of almost 100 per cent.

Figs. 7 and 8 were taken from the 18 x 24 steam cylinder actuating the above compressors, and show the amount of power required to do the work shown in Fig. 6. The steam pressure in boiler was 72 lbs.; the initial pressure of card, 68 pounds; the mean effective pressure, 32.55; the actual power required, 42 H.-P.

Fig. 9 shows diagram taken from a 12 x 24 compressor during actual work. The direct pressure, in this case, equals 127 lbs.; the back pressure, 14 pounds; the actual power indicated by card, 27 H.-P.; the power measured to adiabatic curve, 31.7 H.-P.; the power econ-

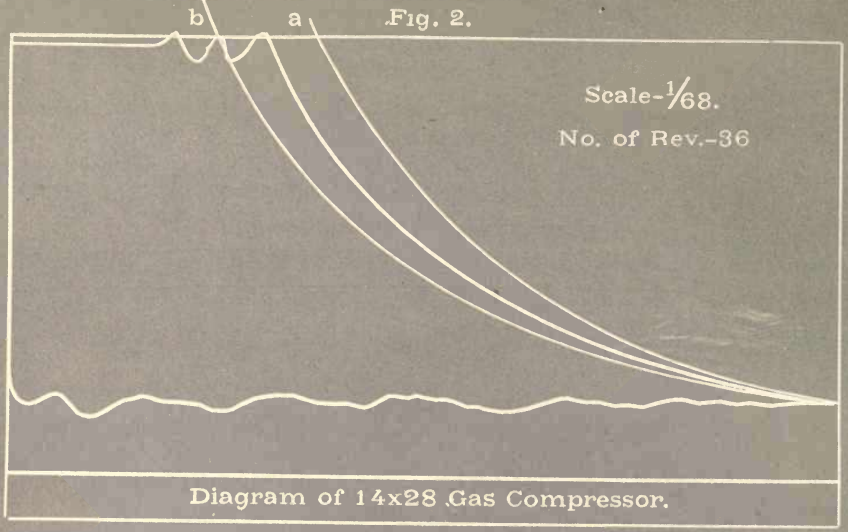


Diagram of 14x28 Gas Compressor.

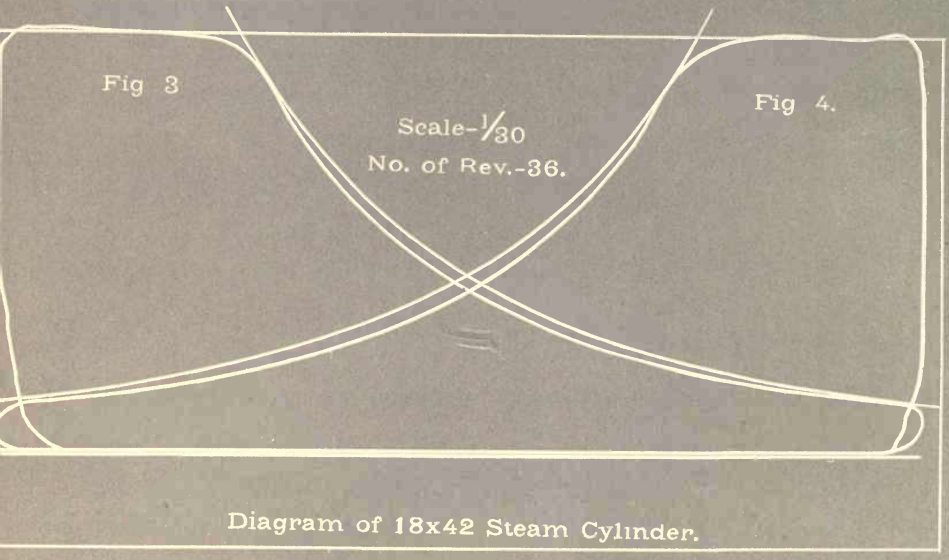


Diagram of 18x42 Steam Cylinder.

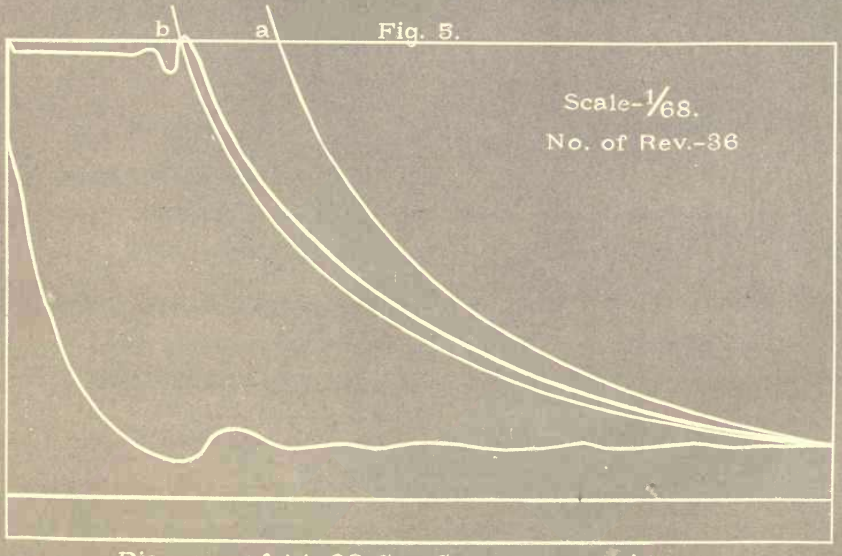


Diagram of 14x28 Gas Compressor without the cooling, sealing and lubricating liquid.

Fig. 6.

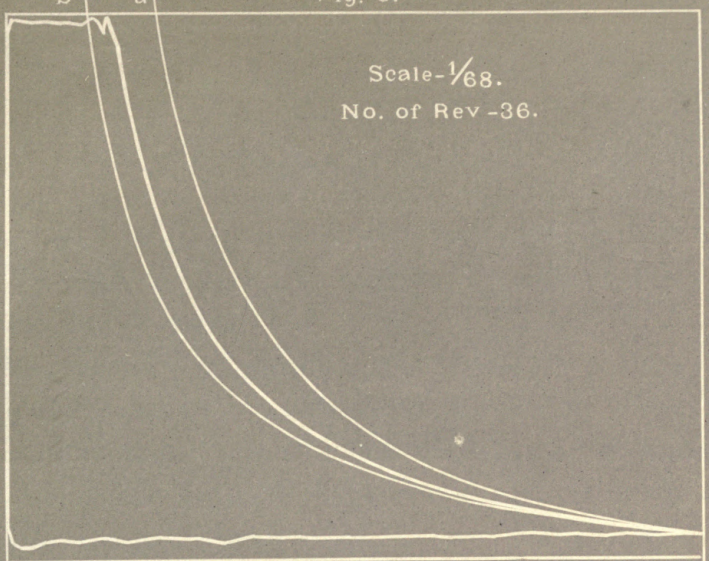


Diagram of 12x24 Gas Compressor.

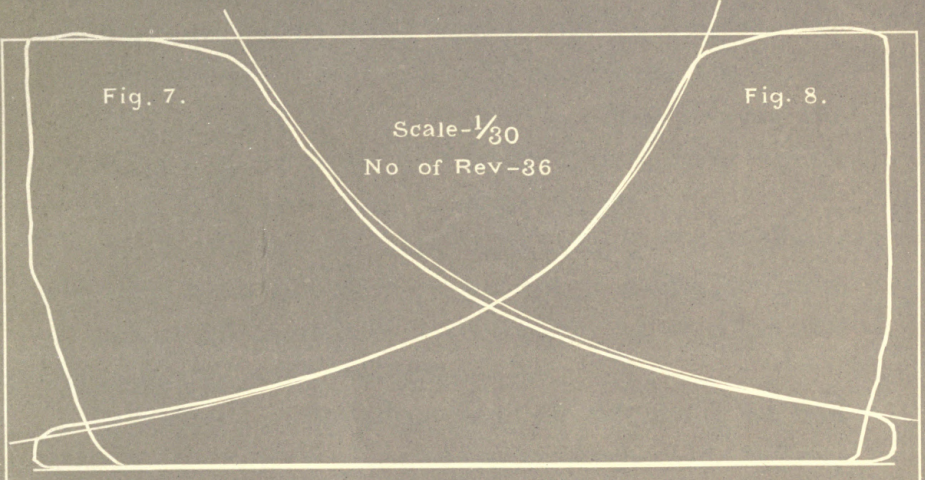


Diagram of 18x24 Steam Cylinder.

Fig. 9

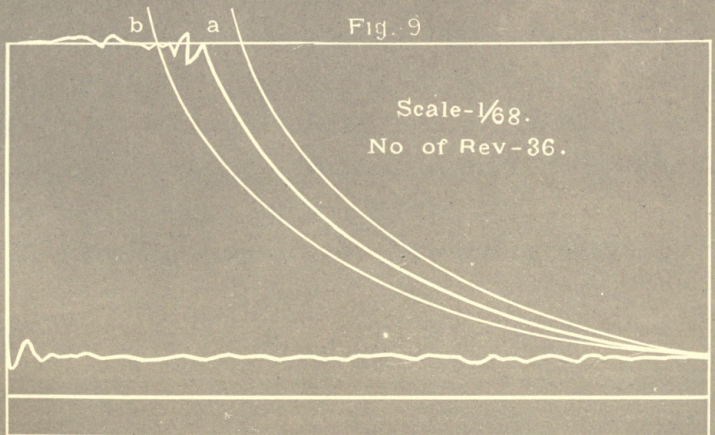


Diagram of 12x24 Gas Compressor.

omized with sealing and lubricating liquid equals 4.7 H.-P. for each compressor, making a total of 9.4 H.-P for both compressors.

The efficiency in pumping gas is 99.4 per cent.

By these means we have been enabled to obtain an efficiency from our pumps equal to 98 or 99 per cent. of their theoretical duty, as the adjoining plates of indicator diagrams will show.

We particularly invite the owners and operators of gas compressors differing from our own to have indicator-diagrams taken from theirs, and to compare the cards with ours. To those who understand the meaning of such diagrams, they will at once indicate the superiority of our system of using a lubricating liquid, as the gain in power can be easily traced.

For the benefit of those unfamiliar with indicator diagrams, we will state hereafter the economical results accomplished by machines erected by us, as compared with those of other builders.

In addition to the advantages already cited, we find that the continuous lubrication as applied in our machines materially reduces wear, so much so that but few repairs are necessary.

After ten years' use our cylinders are still in good condition and do not require reboring, whereas it is not an unusual thing with other builders to have theirs rebored after one or two seasons' use, at the end of which time we have found the wear upon ours so slight as not even to have effaced the tool marks

We therefore think we are justified in claiming that

our compressor is not only the most economical one in the market to operate, but that it is also the most economical one to maintain and keep in repair for any number of years.

These are important considerations to establishments using Refrigerating or Ice Machines.

## CONDENSERS (PATENTED).

In the apparatus required for the second operation of the cycle already mentioned, wherein the heat is abstracted from the compressed gas, we have made considerable improvements over previous practice. As already stated, all gases when compressed are decreased in volume and increased in temperature, and to produce liquefaction in the case of a liquefiable gas, it has to be cooled by some means *which nature affords*. The cooling process first abstracts the sensible heat of the gas, until it has reached its point of liquefaction. In this condition any further cooling liquefies a portion of the gas, and this goes on continually until all the gas is condensed, always provided, however, that the pressure is kept up by the continued operation of the compressor. In this manner the latent heat of the gas is carried away, as heretofore described.

The medium usually employed for cooling is water at as low a temperature as it can be obtained with economy; the colder the water the less of it will be re-

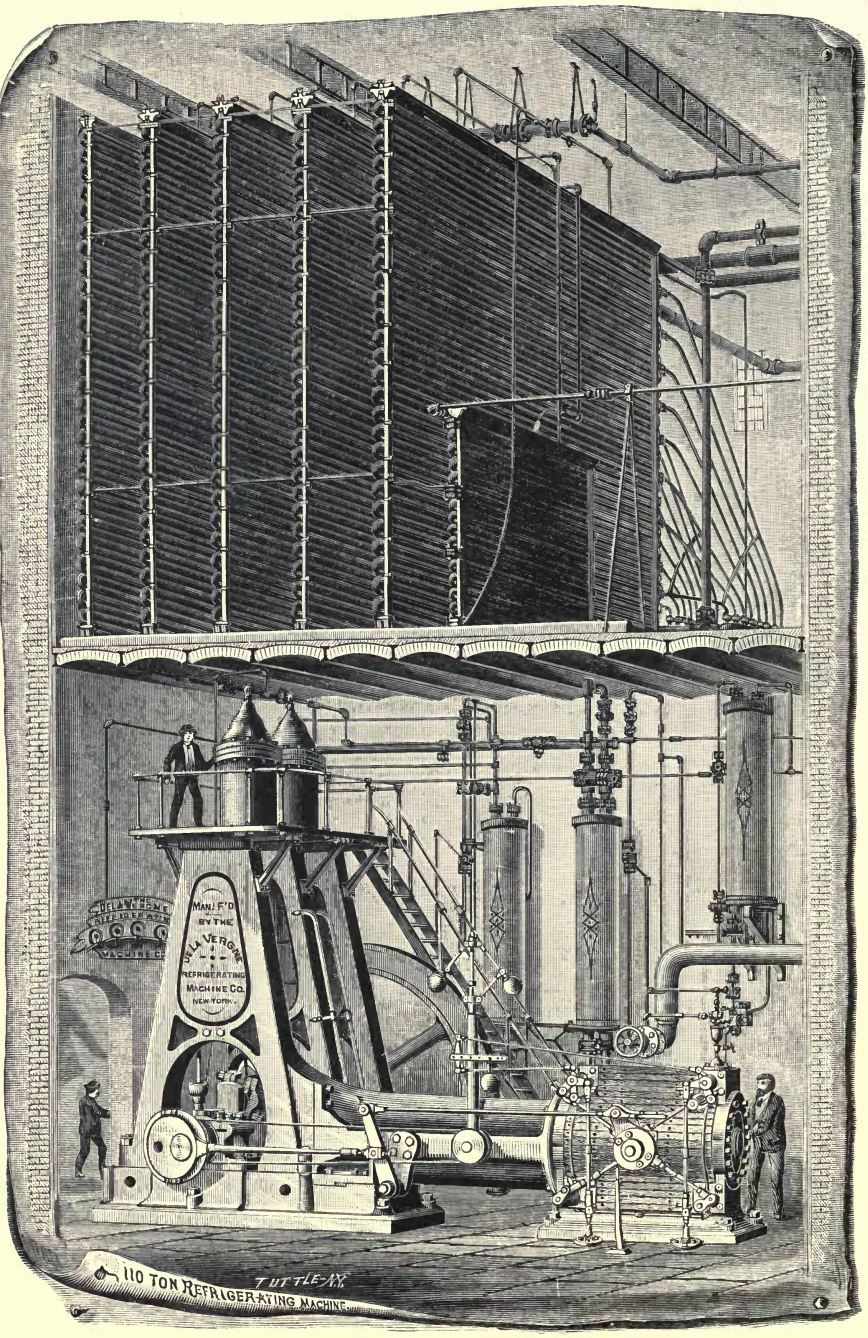


PLATE 8.—110-ton Machine, with Condensers on floor above.

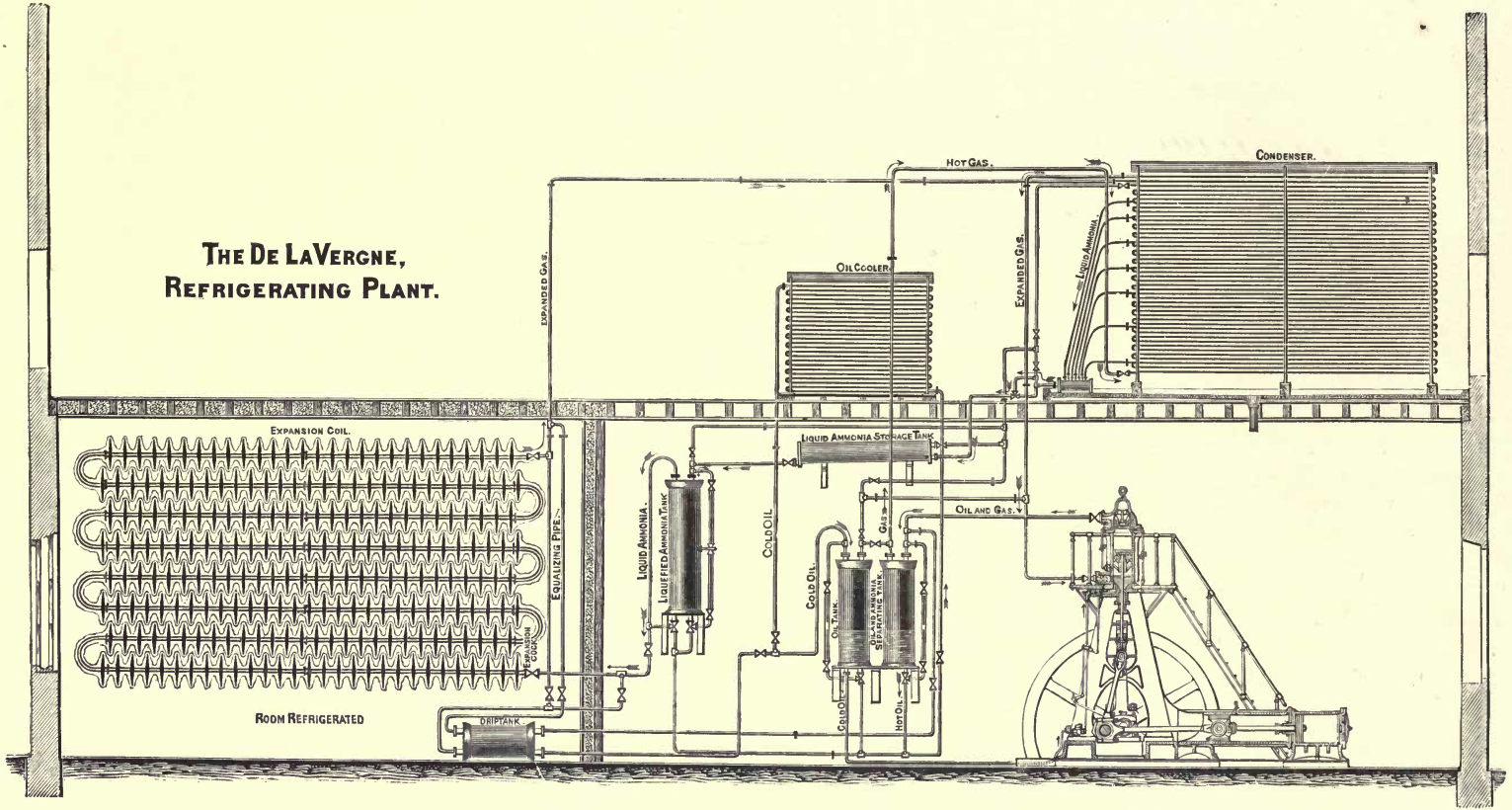


PLATE 9.—Refrigerating Plant—Old System,

quired, and it should, if possible, be free from deleterious substances, so that after performing the cooling required it can be used for other purposes.

A form of condenser frequently used consists of a coil of pipe submerged in a tank through which water circulates; the gas entering the coil is deprived of its heat and becomes liquefied.

Another form of condenser consists of a coil placed vertically, with a gutter at the top of the supporting frame, from which the cooling water is delivered in fine streams or showered upon the upper pipe, and as it trickles downward, from pipe to pipe, its temperature is increased as it descends, by its absorption of heat from the liquefying gas.

The condenser adopted by us is of the latter class, but possesses features of advantage which are entirely lacking in the ordinary vertical condenser, and which will be fully demonstrated by the following cuts:

Plate 8 shows one of our 110-ton machines, with the condensers on floor above. The small pipe-coil on the right side is the oil-cooler, through which the oil passes from the compressors, and where it is cooled by the showering water prior to its re-introduction into the compressing-pumps for sealing, lubricating, and cooling purposes. At the end of the condensers will be seen a series of small pipes, called the "liquid pipes," which are united for each condenser into one short pipe of larger diameter, called the "liquid header," more clearly shown in Plate 9, which represents in one single elevation the whole process through which the oil and am-

monia pass in our system. The liquid pipes serve to carry away the condensed ammonia from separate sections of the condensing coil, so as to keep the latter "dry," and to the fullest extent utilize its surface for the purpose of abstracting heat from the gas.

The defects which have been found to exist in submerged condensers are as follows:

1. The film or stratum of warmed water which forms around each pipe, and large quantities of air-bubbles adhere tenaciously to the same, and materially interfere with the cooling action of the water entering at a lower temperature.*

2. A considerable portion of the water passes by the pipes without coming in contact with their surfaces.

3. Leaks of ammonia can with difficulty be detected, the water readily absorbing the gas, and thereby hiding its loss.

4. The pipes being submerged are almost inaccessible for inspection and cleaning; and for this reason they corrode and wear out rapidly.

Vertical condensers *as generally constructed*, viz., so that the gas has to enter at the top, are subject to the following defects:

1. Only a portion of the condensing surface is utilized; for when the warm gas enters at the top of the condenser in the pipes around which the coldest water flows, only the upper surface of the condenser is of service; the water being so warm after it has descended a

*J. P. Joule "On the Surface Condensation of Steam."—Philosophical Transactions of the Royal Society, London, 1861, page 133.

certain distance as to render the lower pipes of but little use.

2. An exorbitant quantity of water is required, and much of it is wasted without performing any cooling.

3. A higher working pressure is maintained on account of the imperfect utilization of the low initial temperature of the water, for the hot gas meeting the cold water will immediately impart heat to it, and liquefaction can only follow after this has taken place. The liquefied gas now runs down from the top to the bottom pipe simultaneously with the water, which gets warmer and warmer during its descent, and in the lower pipes re-evaporation of a part of the gas condensed in the upper pipes must take place. This is not only a loss, but a result in opposition to that which is sought to be obtained.

Our condenser, as shown in the cuts, resembles in principle the Baudelot cooler of the brewer, which has proved the most efficient form of cooler yet introduced for rapidly extracting heat from a liquid with a minimum quantity of cooling water. As applied by us to the cooling and liquefaction of ammoniacal gas, we claim, and are ready to prove, the following points of excellence over the condensers used by other manufacturers:

1. *Economy of Water.*

By reason of the thin stratum of water passing over the pipes, and it being kept in a constant rolling motion by the velocity of the flow, and its direct contact with the pipes, we entirely avoid the surface film of water

which adheres so tenaciously to the pipes in submerged condensers.

By admitting the warm compressed gas at the bottom instead of at the top of the condenser, as practiced by some others, we expose the warmest gas to the warmest water. The gas ascending in the condenser constantly meets colder water until its temperature is almost reduced to the temperature of the water where it first comes on the condenser, when liquefaction takes place; the water, on the contrary, in its downward passage meets warmer gas and is thereby increased in temperature until it finally leaves the condenser at the bottom, charged with more heat than the same quantity would otherwise be capable of extracting.

In consequence of the gradual extraction of heat just described, the difference between the initial and final temperatures of the water is greater than can possibly be obtained in any other form of condenser. More heat is extracted for an equal quantity of water used, therefore less water is required. This last will be apparent to the brewer, should we ask him to cool his hot wort by allowing the cold water to enter the top instead of the bottom of his Baudelot cooler. The natural result would be that instead of using from one to two barrels of cooling water per barrel of wort, he would require twenty to thirty times that quantity, and still be unable to reduce the temperature of his wort to the proper degree.

The loss attending "spattering" is thoroughly prevented by attaching fins, or strips of metal, to the under

sides of the pipes which lead and guide the water in its descent.

2. *Reduction of Working Pressure.*

In bringing the coldest gas in contact with the coldest water, we can achieve liquefaction with a pressure almost due the *initial* temperature of the cooling water.

By means of the intermediate or liquid pipes connecting with the main pipes of the condenser, we carry off the liquefied gas as fast as it forms, thus preventing its descent to the lower and warmer pipes of the coil and its consequent re-expansion, which would materially increase the pressure.

3. *Reduction of Friction.*

By using pipes two inches in diameter *for our condensers*, the internal friction of the gas is considerably diminished.

4. *Accessibility of parts.*

By reason of our peculiar construction all parts are easy of access and can be readily cleaned.

The condensers are so attached to the main pipes that any one can be readily emptied, disconnected, cleaned, or painted, without interfering with the working of the others.

5. *Superior Construction.*

All the pipe connections of our condensers are made with our patented screwed and soldered joints, and our own fittings (a description of which will be found further on); while other makers use either the ordinary pipe

joint, with or without a wash of solder on the surface, or with rubber washers. By thus rendering our joints absolutely gas tight, we save annually a large amount of ammonia, and obviate all other troubles incident to the escape of the gas.

6. *Economy in Fuel*

Is attained—

By reducing the direct pressure of the compressed gas ;

By reducing the compression-curve through internal cooling;

By reducing the friction in the gas-compressor;

In requiring less water to be elevated to do the work.

The above economies, especially those of the water, will be set forth more fully in describing the results accomplished with some of our plants. It will not be amiss to state here that competitors often claim to do a maximum amount of work with a minimum quantity of water, but these claims are theoretically as well as practically impossible. Any one familiar with the laws governing the transmission or conduction of heat will see at a glance, from the explanation we have given of the different systems, that such claims are practically impossible.

We have an experimental condenser erected at our works, which admits of the introduction of the hot gas into the top or bottom, or at intermediate points and we shall be pleased to have those interested in the subject call and witness a demonstration of the foregoing statements.

# SEPARATING-TANKS (PATENTED).

OLD SYSTEM.

THESE tanks perform the auxiliary process of separating the lubricating liquid from the ammoniacal gas before and after its liquefaction.

In referring to Plate 9 again, it will be seen that the gas and the lubricating liquid discharged at each stroke of the compressor are conducted through the discharge pipe to a cylindrical tank placed vertically, from the top of which the gas continues on its passage to the condensers. Any lubricating liquid that may be carried along with the ammonia is conveyed with it through the condensers to a second tank, placed on an incline and called the storage tank. From this the liquid ammonia passes to another vertical storage tank, and here the small traces of lubricating liquid, mixed with the ammonia, separate from the latter in settling down to the bottom, the oil being heavier than the ammonia. From time to time this oil may be drawn off through certain pipes and cocks arranged for the purpose into the first separating-tank, which is located somewhat lower down.

The lubricating liquid deposited in the first separating tank is warm, having in its passage through the compressor abstracted heat developed during compression. From the bottom of this tank it is conducted to a vertical coil of pipe—the oil cooler, over which water trickles

—and by this means is cooled, and then discharged into another tank, the cold-oil tank, from which it is pumped or forced by pressure to repeat the same round of operations. Other builders not being in a position to use the lubricating liquid in the manner described, do not require the separating-tanks, coils, etc., above mentioned. These auxiliaries increase the first cost of our machine, but the purchaser is amply repaid by the economy of fuel, water, repairs, etc. We consider the use of the lubricating liquid in this manner one of the most economical features of our entire system.

In order to control the flow of the liquid through the system an oil-regulating cock is placed in the pipe, connecting the first separating or hot-oil tank with the cold-oil tank. Glass gauges attached to the tanks permit of ascertaining the height at which the several liquids stand in the tanks, thus furnishing to the attendant a complete control of the apparatus.

### NEW SYSTEM.

In our new and improved system of oil-circulation we have considerably simplified the process of handling the oil in its course through the compressors.

In the first instance we do not any more use the low-pressure or cold-oil tank. By exposing the oil to the low-pressure of the suction side it lost some of the gas held in solution at the high-pressure of the condenser. This gas passed into the compressor without doing any efficient cooling and resulted in a loss of capacity of the compressor. While this loss was small, still we have

obviated it by not exposing the oil to any lower pressure than the condenser-pressure before it re-enters the compressor. In this manner we have not only gained as much as it was possible to gain, but we have simplified the system by the elimination of the low-pressure oil-tank. The second separating-tank, the one which separates the oil from the liquefied ammonia, is now placed by the side of the first or high-pressure tank, and thus the oil system is considerably simplified. Instead of "injecting" the oil through an injector into the compressor, we now use an oil-pump, which always supplies the gas-pump with a measured quantity of oil at each stroke; and in case of the double-acting compressor it supplies this oil during the compression-period of the piston, which is the proper time to do it, because during compression heat is developed and the oil then fulfills its purpose of carrying away the heat of compression.

Plate 10 shows our new system of separating-tanks, and in following the arrows the process through which the ammonia and oil pass is clearly seen, in the drawing of the new system as well as in the one of the old.

## EXPANSION COILS.

In passing to the third operation mentioned in the beginning of this book, we will state that we prefer to refrigerate establishments by expanding the gas direct through pipes placed in the rooms to be cooled, and not by first cooling a non-congealable salt brine and pump-

ing this through pipes in the rooms. The reason for this is that a loss of efficiency is always connected with every transmission of heat. We can carry an evaporating pressure in our direct pipes of 25 pounds and still have within them a temperature of 14° Fahrenheit, while only 15 pounds can be carried in the evaporating coils to keep the brine at 18°. The result is that we suck the gas into our compressors at a higher back-pressure than if we first cool brine; and, as explained before in enumerating the advantages of ammonia over other agents, we get a greater efficiency from a certain compressor the greater the pressure is at which we take in the gas. Furthermore, we produce the cold just where it is wanted, and lose nothing, while in the brine system a large tank is exposed to the atmosphere, and—even if insulated—absorbs a great deal of heat, which is a total loss. To pump the sometimes immense masses of brine through thousands of feet of pipes, which after a while become coated on the inside with rust and slime, and thereby produce great friction and non-conductibility, costs a considerable amount of steam, so that through all these different causes combined we increase the efficiency of our machines on account of the direct expansion alone from 20 to 25 per cent. The objection raised against placing the ammonia pipes direct into the rooms to be cooled, that there is danger of leakage, we have met by a most perfect system of pipe connections and cocks, which we shall describe further on. All pipes are tested singly, before they are put up, to 1,000 pounds hydrostatic pressure per square inch; and after they are all con-

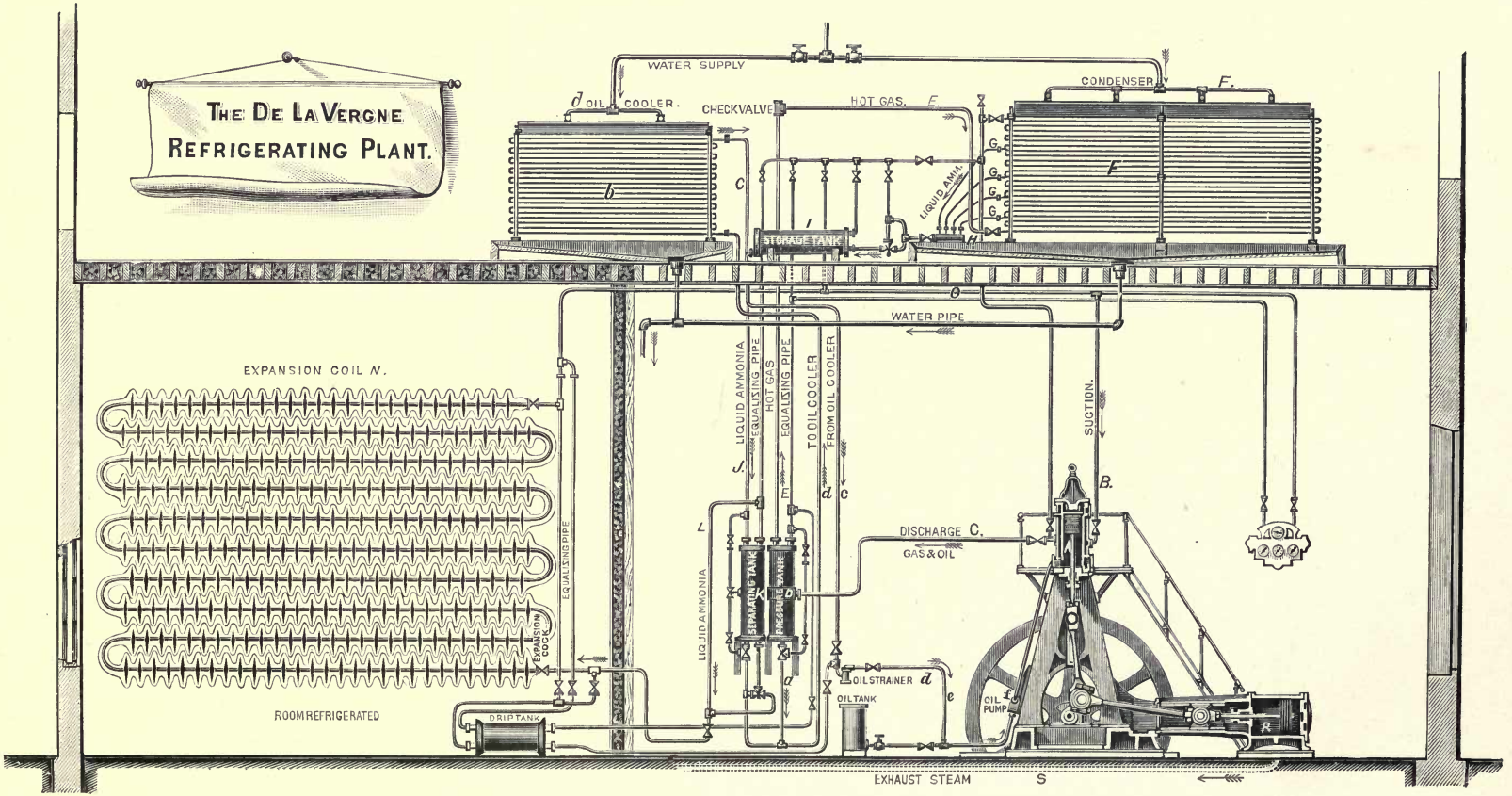


PLATE 10.—Refrigerating Plant—New System.

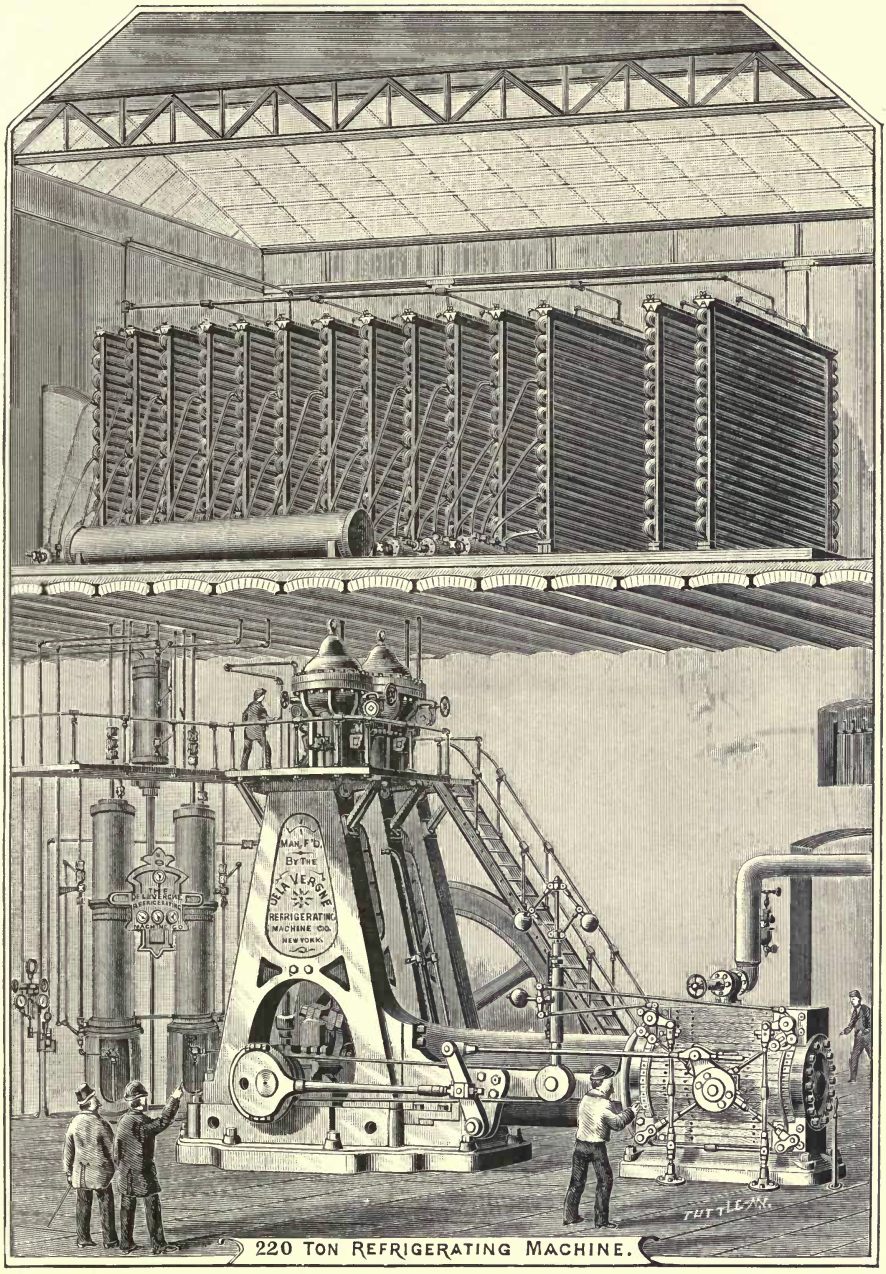


PLATE II.—220-ton Refrigerating Machine, with Condensers above.

nected, the whole system is subjected to an air-pressure of 300 pounds, at which the gauge must remain for hours in succession. In this manner we produce a plant that is many times safer than any steam-boiler; and since the first machine was erected, in 1879, and with over 700 miles of pipes now in operation, we have not a single accident yet to record. The size of pipe adopted by us for the expansion coils is 2 inches diameter, and we give preference to this size for the reason that it is lap-welded, whereas the smaller sizes are butt-welded; and also on account of the diminished friction of the gas in passing through pipes of this diameter.

Formerly we used pipes *only* to obtain the necessary cooling surface in the rooms to be refrigerated; but since 1882 we have accomplished the same object by means of cast-iron disks, which are made in halves and attached to the expansion coils, after these are all put up, by means of iron clips, which press the two halves together against the pipes. We thereby increase the cooling surface to such an extent that we now need only one foot of pipe where formerly we required four, thus saving in room and first cost.

The application of the disk is based upon the principle now used in the most efficient of our modern steam radiators, in which the heating surface exposed to the air is increased by means of flanges and projections added to the outside surface of the radiator; thus exposing a larger heating surface than was attained with the old form of steam coils.

By applying our disks to steam coils, the same results

could be obtained as with the modern steam radiator; the transmission of heat could be increased or diminished according to the number of disks applied to each lineal foot of pipe.

The results obtained are based upon the fact that heat is conducted with more rapidity by iron than by air. Whereas, one square inch of iron will transmit, say, fifty heat units per minute to another piece of iron attached to its surface, it will transmit but one heat unit, under similar conditions of temperature to air.

In order to make a refrigerating coil quick and effective in reducing the temperature of air, we bring the air in contact with as large a refrigerating surface as practice admits of, without, however, increasing the internal surface bathed with the chilled liquefied ammonia to more than is absolutely necessary.

We make four sizes of disks—three round, 6 inches, 10 inches, and 14 inches diameter respectively, and one of oval shape, 10 inches by 15 inches—in order to accommodate them to the room and purpose to be accomplished. Plate 12 shows these disks in half-sections, and also as they appear attached to the coils.

In answer to frequent inquiries, it will not be amiss to repeat here that ammonia has no chemical effect upon iron; a tank, pipe, or stop-cock containing ammonia in a gaseous or liquified condition will stand an indefinite time, and upon opening no action will be apparent. We have had pipes in use ten years, the inside surfaces of which have not changed one particle. The only protection, therefore, that ammonia-expanding pipes require is

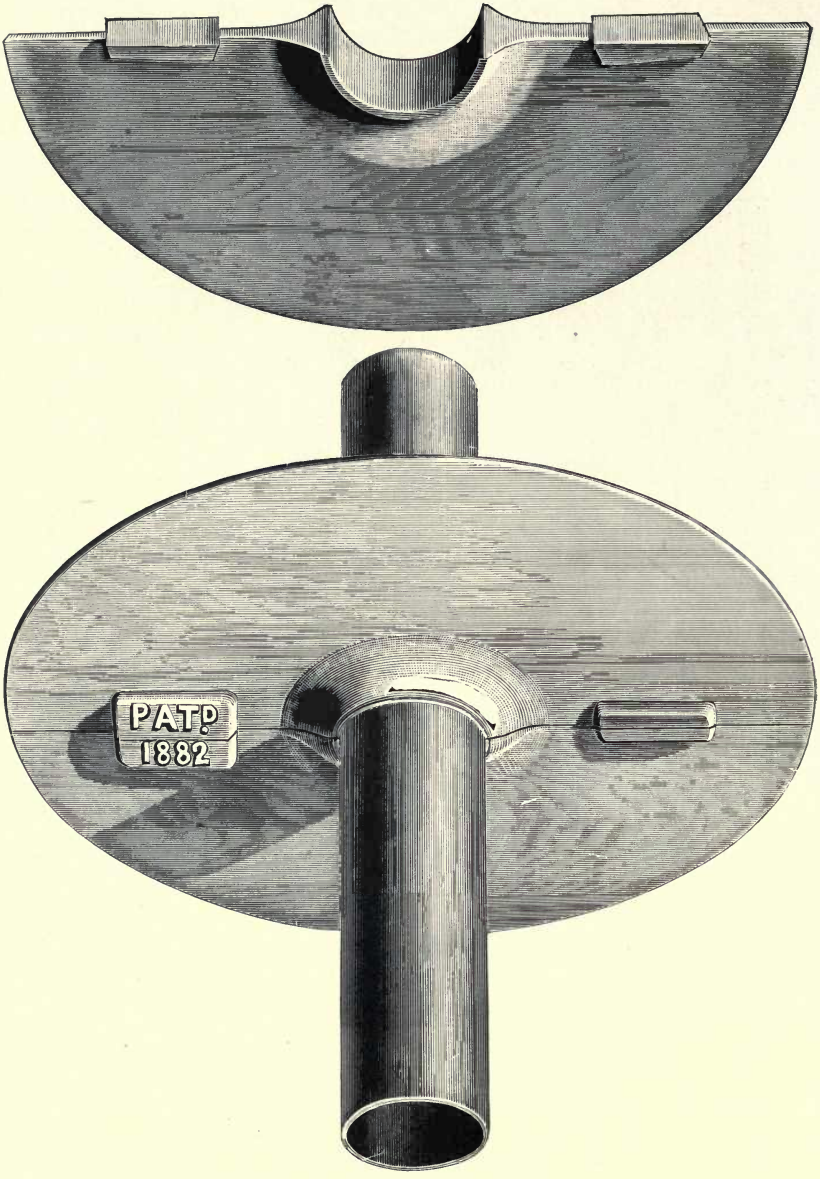


PLATE 12.—Disks for Expansion Coils.

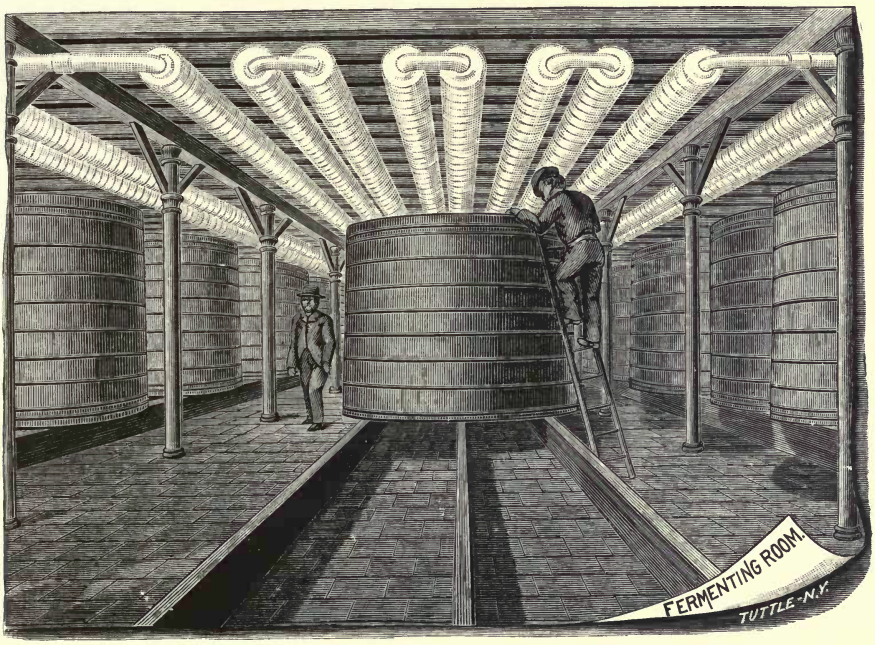


PLATE 13.—Fermenting-Room.

from corrosion on the outer surface. As long as the pipes are covered with snow or ice corrosion does not occur ; the coating of ice thoroughly protects them from the oxidizing effect of the atmosphere; but alternate freezing and thawing requires protected surfaces, which are best obtained by applying a coat of paint every season.

We aim to do thorough, good work, and spare neither expense nor pains to give our customers the very best machines and plants which can be obtained; both as a whole and in minute detail. This, no doubt, is expensive, but the resulting economy in working, and the immunity from accidents and stoppages, more than compensate for the interest upon the increased cost.

Our expansion coils having to withstand but a maximum working pressure of thirty pounds per square inch, are constructed with such absolute security, in whole and in detail, as to make them one of the most perfect pipe constructions on a large scale ever applied in practice.

## BRINE-COOLING COILS.

When preferred by our customers, or where the circumstances make it desirable, we are also fully prepared to apply the "brine-circulating system," which consists simply in cooling any saline solution, such as chloride of calcium, chloride of sodium, chloride of magnesium, etc., and circulating the chilled solution by means of

pumps, either in closed pipes or open troughs through the rooms to be refrigerated.

The ordinary method employed in abstracting heat from the brine is to inclose the brine in a large tank supplied with vertical coils, in which the chilled liquefied ammonia circulates, vaporizes, and returns as a gas to the compressor. These submerged coils are usually supplied with expansion valves attached to their lower ends, their upper ends connecting by a main pipe with the suction side of the compressor. The brine, deprived of a portion of its heat, is drawn away by the circulating-pump, and forced to circulate through the gutters or coils suspended in the rooms to be cooled; in its passage it abstracts heat from the air in the room, is thereby increased in temperature, and, returning, enters at the top of the tank to again go through the same operation.

## AMMONIA BAUDELOT COOLER (PATENTED).

In the manufacture of lager beer it is not only necessary to reduce the cellars and chambers used for storage and fermenting purposes to a low degree, but additional refrigeration has to be performed in reducing the temperature of the wort, to prepare it for fermentation.

The process hitherto employed by brewers using natural ice has been to force ice-water into the bottom of a vertical coil, over which the warm wort trickles,

and is thereby reduced in temperature. To economize in the consumption of ice, the majority of brewers employ a double cooling system by separating the vertical cooler into two coils; through the upper one well-water is forced, and the temperature of the wort reduced to about 60 degrees Fahrenheit; through the lower one ice-water circulates, which, in turn, reduces the temperature to 40 degrees Fahrenheit. In breweries supplied with the refrigerating machines of other builders, the ice-water employed above is replaced with brine or water cooled by the machine; submerged expanding coils being used to effect the refrigeration. After the completion of our improved compressor, the first thing that attracted our attention was the roundabout way employed by other builders in reducing the temperature of the wort. They require coils to reduce the temperature of the brine or water, a circulating pump, and an additional coil through which the cooled brine or water has to be forced in order to reduce the temperature of the wort. If a machine is obliged to cool brine or water from say 60 to 33 degrees Fahrenheit, and circulate it as above described, in order to accomplish the work required, why can it not cool the wort direct, and thus avoid the use of a circulating pump and tanks, and also the loss occasioned by the absorption of heat by the brine before the latter is brought to do its work, to say nothing of the loss occasioned by being obliged to reduce the cooling medium five and even eight degrees below that of the wort cooled?

In answer to the above question, we can safely as-

sert that the direct system is the only one the brewer should apply to the cooling of his wort.

As the work required to be performed in reducing the temperature of the wort amounts to almost one-third of the entire refrigerating work of the brewery, and to more than the work done in all the rest of the brewery during the time the wort is being cooled, it is essential that the brewer should consider thoroughly which system is the most economical one to adopt; and to aid him in this we have compiled in the following a brief statement of the advantages offered by our system:

1. *Accessibility of Parts.*

The cooler is located and erected by us in a manner similar to the ordinary Baudelot cooler.

Where a well-water cooler and the proper height exist, we place our cooler below the water cooler already in use in the brewery, and thus obtain a location easy of access from all sides.

2. *Superior Construction.*

We have formerly used for the direct expansion Baudelot iron pipes covered with copper. This was done because in most cases the brewer desired to have the cooler match the one he had in use for forecooling the wort with water—and this is in all cases made of copper pipes. In the course of our experience, however, we have often obtained from the manufacturer iron pipes over which the copper was so loosely drawn that it seriously impaired their efficiency, and in some cases abso-

lutely preventing the apparatus from doing its work. The thin stratum of air intervening between the iron pipe and its copper covering effectually prevented the conduction of heat. When we were first brought face to face with such a case the copper was stripped off, and the result was a much more efficient cooling than we had ever done before. We now recommend a plain iron pipe cooler as being more efficient and cheaper. The pipes are all ground bright with an emery-wheel, and the coating which is imparted to them by the wort after they have been used several times, absolutely prevents their rusting even if they are not rubbed dry after wort-cooling. By special request, however, we still make the copper-covered cooler

3. *Rapidity of Cooling.*

By employing our direct system, the cooling of the wort can be effected at any rate of speed desired. Whereas it is necessary with the indirect system to run the compressors some eight or ten hours, in order to store a large enough volume of cold water or brine to effect the cooling of the wort, we require but a minute's notice to open the expanding-cock and put the cooler in operation.

4. *Ease of Management.*

With our improved form of expanding stop-cock the flow of liquefied ammonia entering the cooler can be regulated to such a nicety that the wort is delivered into the fermenting-tubs at the exact temperature the brewer requires.

5. *Increased Efficiency.*

By extracting the heat direct from the wort we dispense entirely with an intermediate agent, such as water or brine, and thus avoid the loss of efficiency occasioned in the absorption of heat by the cooled water or brine during its period of storage and circulation.

6. *Economy of Fuel.*

The higher the pressure at which the expanded gas returns to the compressors, the greater will be the amount of work performed per stroke; consequently the higher the back-pressure at which a machine can do its work effectively, the greater will be the weight of gas compressed and liquefied at each revolution.

In cooling the water or brine used for circulating through the wort cooler, the back-pressure in the compressors of other builders amounts to from 15 to 20 lbs., whereas in cooling the wort direct by our system a back-pressure of from 30 to 40 lbs. can be maintained. We therefore do over 50% more work at each stroke of the compressor than we could accomplish in applying the old system, and thereby obtain a corresponding economy in fuel. By expanding the gas only where refrigeration is wanted nothing is lost, but everything is utilized; we therefore compress a smaller weight of gas to do the same work than would be required in indirect cooling, and fuel is economized in consequence.

The brewer finds it an advantage to employ the Baudelot cooler for his wort—he economizes in water,

ice, and coal; its superior efficiency justifies him in adopting it. For the same reason, our system will eventually be preferred to all others.

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## ATTEMPERATOR-SYSTEM (PATENTED).

In breweries there is, in addition to the cooling of the cellars and the wort, a third duty to be performed by the refrigerating-machine, viz., the cooling of the beer in fermentation. Where ice is used this is accomplished by so-called "swimmers"—conical vessels made of tin or sheet-copper. Whenever the temperature of the beer in a fermenting-tub rises too high, so that fermentation proceeds too fast, a swimmer is put into this tub, where it floats on the surface of the beer. Ice is put into the swimmer, and the temperature of the beer is lowered by its contact with the cooling surface of the swimmer. The labor, however, in handling such cumbersome vessels, the frequent occurrence of their "drowning," and the difficulty of easy regulation of the temperature, have resulted in replacing the swimmer by the "attemperator," which consists of a coil of iron or copper pipe, placed in the tub. The coils of all the tubs are supplied with cold water (at about 34° Fahr.) from a separate steam-pump called the attemperator-pump. Each attemperator has an inlet and an outlet valve, which connect it with the supply and return main, so that the circulation of cold water through it can be regulated at

will, and thus the temperature of each tub kept where it is desired in order to properly conduct the process of fermentation. In breweries refrigerated by ice, the cold water is supplied from a tank, tub, or cistern, in which ice is constantly kept in sufficient quantities to maintain the water at a temperature a little above freezing. The water, after having traversed the attemperators, is returned to the ice-tank only slightly warmer; but it is evident that in the course of time the water must increase in bulk by the melting of the ice, and since nothing can be done with it, the surplus is allowed to run to waste. Where, however, refrigerating machines are used, the water is cooled by evaporating-coils, the same as brine, and as it neither increases nor decreases in quantity there is no wasting of cold water.

In the greater number of breweries using the attemperator-system, the cold water is forced through the coils direct from the pump. The defect of this *modus operandi*, however, is that when more coils are suddenly turned on, and a greater supply of water necessary, the pressure on the other coils is diminished and their supply lessened, unless the pump is watched by somebody and run faster at such times. Still, it was very difficult to maintain the same pressure in the pipe-system, and the regulation of one coil always influenced all the others.

In the system which we employ, the cold-water tank, with its cooling coils, is placed above the uppermost fermenting-room, and the water runs through the attemperators by *gravity*, thus furnishing an absolutely uniform pressure throughout the day, to the whole pipe-

system. In order to control automatically the varying quantities of water needed, a long stand-pipe receives the water after its passage through the attemperators. If *more* water is used and the height of it in this pipe increases, the greater pressure which it exerts upon a small piston is utilized to open the steam throttle of the pump a little more and makes the pump run faster, thus enabling it to carry back to the cold-water tank the increased quantity of water circulated. If *less* water is used the operation goes the opposite way, the lessened pressure of the water column tending to shut off the throttle, and thus reducing the speed of the pump. This arrangement works admirably, and does away with the necessity of having an attendant to regulate properly the speed of the pump. It was invented and patented by one of our customers, but the patent was generously assigned to us by him for our exclusive use.

## OUR PIPE SYSTEM (PATENTED).

Not only has it been found difficult to build a gas-compressor which was efficient and durable, and a stuffing-box of the simplest construction, which would at all times be tight without requiring constant attention and frequent repacking, but a great drawback in the construction of refrigerating machines has been the difficulty of making a pipe-system with its joints and cocks, or valves, which was *absolutely tight*, so that there would

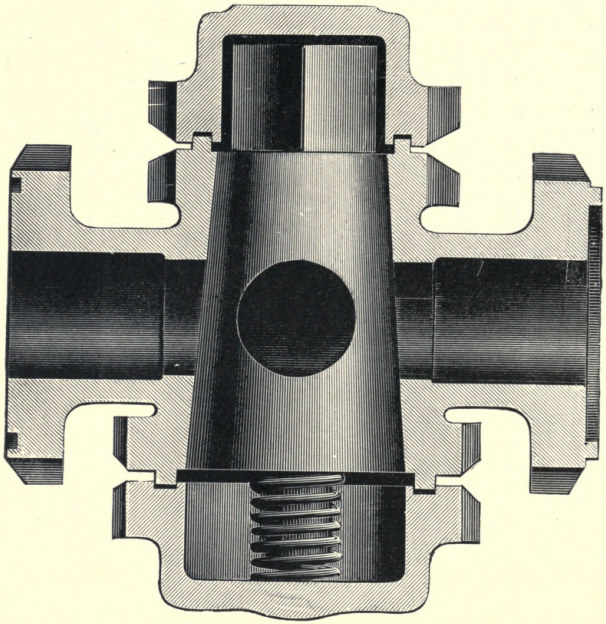
be no obstacle in the way of using as many joints and cocks as was found necessary for a perfect system of direct expansion.

We have succeeded in accomplishing this result, and though it may be considered expensive in first cost, it is certainly economical in the end. A ten years' experience has proved this.

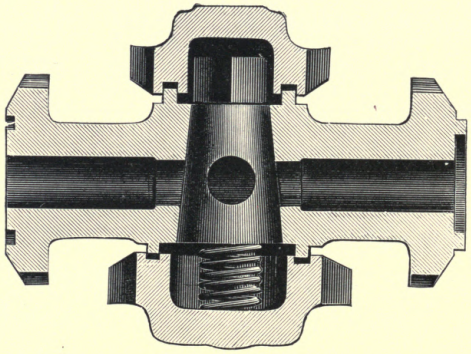
On Plate 14 a 2½-inch and a 1-inch stop-cock are shown. We have bought the patent on this cock, and have found it to answer the purpose in a very perfect manner. It will be seen that over the large end of the cock a cap is bolted, which is made tight by a lead gasket filling an annular recess. Into this recess the male of the cap fits, thus making a tight joint of a durable metal. Between the cap and the plug we insert a spiral spring, which at all times presses the plug on to its seat, so that no impurities can get at the very carefully ground surface, and in this manner we prevent cutting of the surface and ensure tightness.

Plate 15 represents our ½-inch expansion-cock, used to regulate the flow of liquid into the expansion-coils. Since this regulation has to be of the very nicest kind, we have constructed the passage through the plug in the following manner: The round opening does not entirely pass through, and the thin remaining bridge of metal is perforated in the shape of a very narrow wedge, the point of which is the first to open. Movement is imparted to the plug by a worm and worm-wheel, thus ensuring adjustment of a most delicate character.

To ensure perfect tightness between the pipes proper



2½-inch Stop-Cock.



1-inch Stop-Cock.

PLATE 14.—Stop-Cocks.

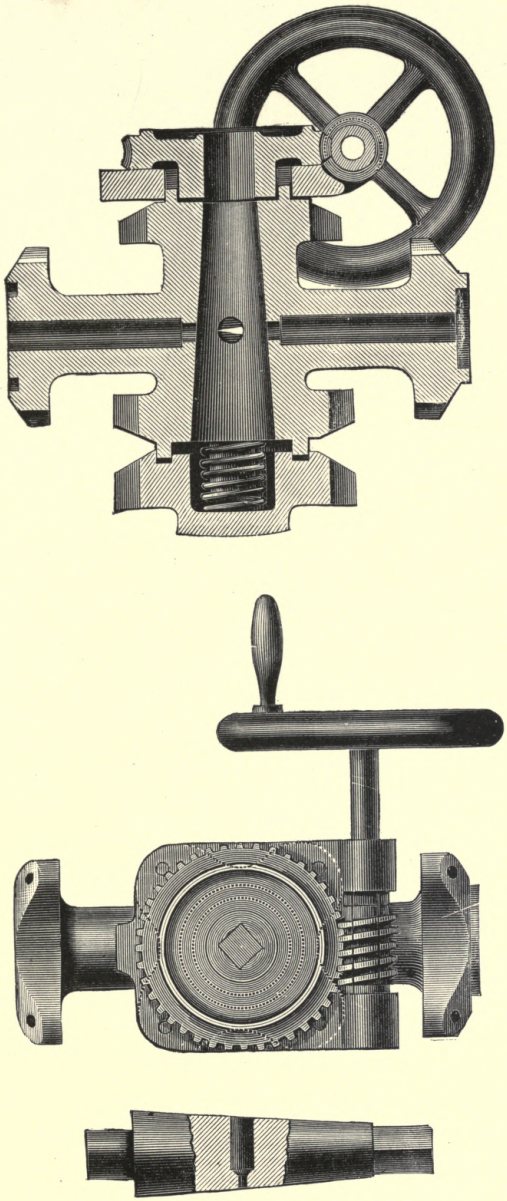
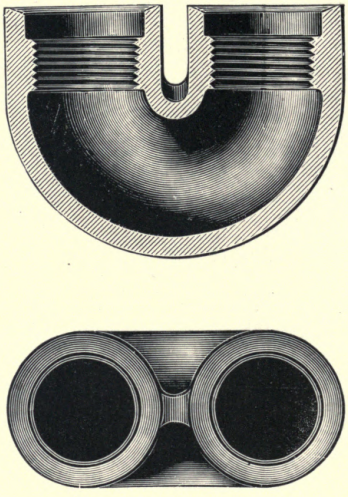
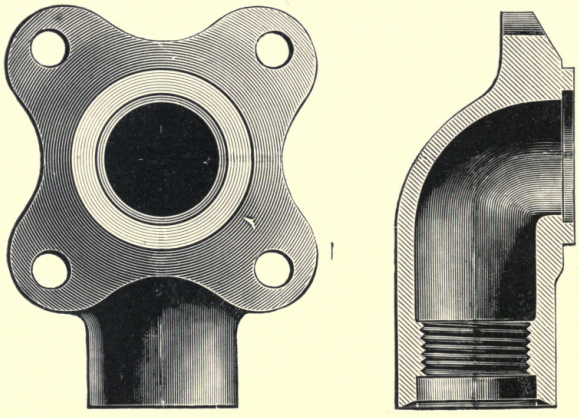


PLATE 15.—½-inch Expansion Cock.



2-inch Return Bend.



2-inch Return Bend Flange.

PLATE 16.—Fittings.

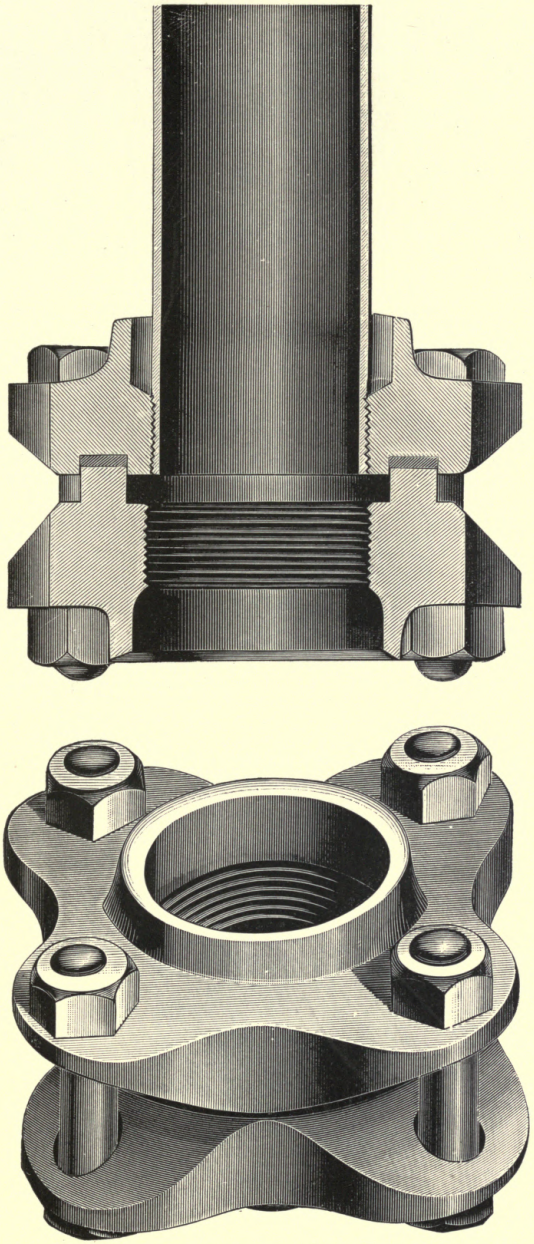


PLATE 17.—2-inch Flange Union.

and the fittings to which they are attached, we have invented and patented a joint which we call the "screwed and soldered" joint. In the selection of fittings, which are shown on Plates 16 to 18, it will be seen that the thread into which the pipe screws does not reach entirely to the outside. It is enlarged to the depth of ½ to ¾ of an inch, forming a smooth annular space around the pipe beyond the termination of its thread. All our fittings are made of malleable iron or steel, which admit of being well tinned, and thus we form a screwed and soldered joint by entirely filling the annular recess, formed on the outside by the fitting, and on the inside by the pipe, with solder. The result is that the thread of the pipe is entirely covered and that the otherwise weakest part of the pipe is made the strongest. In over-running our test-pressure of 1,000 pounds to the square inch, at which all our pipes, fittings, and cocks are tested to the point of bursting, we always rip open the pipe before this joint gives out.

The flange-union shown on Plate 17, by which two pieces of pipe connections are bolted together, is made tight by a lead gasket, as has been described in connection with our stop-cocks.

It has taken us many years to perfect the pipe-system which we now manufacture. Many tons of defective castings have gone into the scrap-heap, and even to-day the loss on this account is considerable; but by giving our fittings the proper strength and shape, we have reduced this loss to a minimum. The best special tools that we could get in the market have been pur-

chased, and we are to-day in a position to manufacture our specialties as cheap and as good as they can be made.

In our new and extensive works at the foot of East 138th Street we are enabled to turn out our work better and faster than before, and unsurpassed accommodations permit the shipping of our machines by land or water to any part of the United States or to foreign countries.

## THE STEAM-ENGINE.

THE steam-engine which operates a refrigerating machine is certainly as important a part as all the rest, but here we had the selection of a score of good cut-off engines. We have decided on two kinds: The Corliss cut-off for our larger machines, and the Tremper cut-off and governor for the smaller sizes. Both give almost equally good results as far as economy is concerned, and the former is so well known the world over that it requires no further comment. The sectional cut on the first page shows the general arrangement of the engine and compressors. The engine and one compressor are coupled to the same crank, thus compelling the steam to exert its greatest power at the point of greatest resistance of the compressor-pistons. The layer of oil on the stuffing-box of the compressor, over the piston and the dome-valve, by which the sealing of those parts is effected, is also clearly shown.

# THE MACHINE IN THE HERMANN BREWERY.

Mr. John C. De La Vergne, President of this company, began the business of brewing lager beer February 1, 1876, in what is now known as the Hermann Brewery, situated in 18th Street, between 7th and 8th Avenues, New York City.

After his first year's experience in refrigerating the brewery with ice—and considering the outlay required for its purchase, the many incidental expenses and delays attending its handling, the space occupied for its storage, the uncertainty of the ice crop and its increased price, the dampness, waste, slop, and inconvenience experienced in consequence of its use, he was forced to the conclusion that if there were any mechanical means for accomplishing the same or better results, which were practicable and reliable, he would endeavor to secure the same for use in his brewery. From this time his attention was directed to a thorough investigation of the various refrigerating machines upon the market. This investigation fully convinced him that there were really no successful machines in operation adapted to the purpose. The difficulties which presented themselves were the following:

1st. That absorption machines were intermittent in their action, wasteful of water and fuel, and required the constant and watchful attendance of a skillful engineer, one of more than average ability.

2d. That no machine then built was of sufficient strength and capacity readily to perform the work required of it, and they were therefore unreliable.

3d. That the compressors were inefficient and performed but a small percentage of their duty, for the reason that they failed to expel, at each stroke of the piston, all the gas contained in the cylinder.

4th. That most of them leaked gas at the stuffing-box of the piston-rod.

5th. That the gas-compressing cylinders had to be flushed with water on the outside, which absorbed the leaking gas and prevented the detection of leaks.

6th. That the joints of the pipes were imperfect and would not hold the gas under pressure.

7th. That the stop-cocks were not sufficiently perfect and durable.

Mr. De La Vergne decided, however, that if these difficulties could be overcome, nothing would stand in the way of the successful application of mechanical refrigeration to the cooling of his vaults and fermenting rooms.

About this time his attention was drawn to the advantage to be gained by using a liquid to assist in the complete expulsion of the gas from the compressors at each stroke. This idea impressed him so favorably that he immediately commenced to devise plans for its embodiment in a compression pump.

Many drawings were made, and finally plans were so far perfected that he considered it reasonably prudent to build a machine.

It was ordered and constructed in 1878. When completed it was placed in position in the Hermann Brewery, and put in operation. Tests were made to prove its efficiency, and after many days of anxious labor in this direction, he was forced to the conclusion that the time, money, and thought had been expended to very little purpose. The pump would compress no greater percentage of gas than those previously made, consequently would perform no more work, and the experiment was finally abandoned.

Mr. De La Vergne not being satisfied to let the matter rest here, after some weeks of thought and consultation, determined to devise, and, if possible, to put in operation, another machine which would avoid and overcome the difficulties encountered in the first attempt. New plans were accordingly made, and another machine built.

This second machine was finished and set in operation at the Hermann Brewery in 1880, where it commenced at once to do efficient work, and demonstrated that it was a success. The expansion-pipes were then placed in position throughout the brewery, and it was artificially refrigerated to better advantage than previously done by the use of 7,000 tons of natural ice.

Since that time this machine has completely taken the place of ice, and now cools, in an efficient and practical manner, over 175,000 cubic feet of space, and 300 barrels of wort per diem, proving itself as reliable as and much more efficient than natural ice.

The only defect developed in this machine was in

the crank-shaft, which was not made strong enough, and had too many cranks on it. However, it held for the first year; the second year it was somewhat strengthened, but during the winter of 1882 a new shaft was substituted of sufficient size and strength, and separated into two parts similar to those we are now putting in our most improved machines. With this improvement, this first machine is now as successful, and performs what is required of it as perfectly, as any steam-engine. The pumps have never been rebored or repaired, and the tool marks on the inside of the cylinders are not even worn off.

Two of the pumps are found ample to do the work, and in the six miles of pipe attached to the machine and filled with ammonia under pressure, not one single leak is found.

It will be seen from the foregoing statements that the above machine was no inspiration in its development, but was worked up little by little to its present state of perfection.

## ECONOMY OF OUR SYSTEM.

In the first edition of this catalogue we have enumerated the results obtained by us in space cooled per pound of coal consumed, and have also quoted analogous results in breweries cooled with other machines than ours. While ours at that time were from 58 to 69.5 cubic feet cooled per pound of coal burnt per diem,

the results of other machines varied within between 37.5 and 49 cubic feet. Since that time, however, we have, in more instances than one, run up to 120 cubic feet cooled per pound of coal burnt per diem. This has been attained by carefully studying the most favorable conditions of evaporating pressure, length and arrangement of pipe-coils, etc., and we believe that, regarding these things, we have completely mastered the subject; at least, we cannot at this time see in what respect we could improve these conditions. Practical results agree so remarkably well with the theory, that we know we are right.

## COOLING OF ABATTOIRS AND PACKING-HOUSES.

As was the case in breweries, we had to overcome the same prejudice in abattoirs regarding our direct expansion system. Packers were even a little more afraid to introduce the direct pipe-system into their chill-rooms than brewers were to put it in their fermenting-rooms. We have, however, made considerable progress also as to the industry that deals with the preservation of meat; and as we have no failure or accident to record since we introduced our system into packing-houses eight years ago, confidence in it is now well established.

It will be of interest in order to allay the fears of the influence of ammonia on fresh meats to quote an article on this subject published in the issue of *The Scientific American* of July 20, 1889. The article is as follows:

## AMMONIA AS AN ANTISEPTIC.

SOME years ago Dr. B. W. Richardson, in a communication to the Medical Society, called attention to the antiputrescent properties of ammonia, and showed that blood, milk, and other alterable liquids could be preserved for a long time by adding to them certain quantities of solution of ammonia and solid substances, such as flesh, by keeping them in closed vessels filled with ammonia gas. Some doubts that would appear to have been raised as to the results reported, on the ground that ammonia was itself a product of decomposition, induced Dr. Gottbrecht, of the University of Greifswald, to repeat the experiments with the result of practically confirming all Dr. Richardson's statements. After some preliminary experiments, in which animal matter placed in 5% ammonia solution was found free from putrescence after nearly two years, ammonium carbonate was used in place of the free alkali for the sake of convenience. The first experiment made with the washed intestines of freshly killed pigs showed the power of ammonium carbonate to retard putrefaction to be directly dependent upon the concentration of the solution, a 1% solution retarding it until the third day, a 10% solution until about the sixtieth day. When added to gelatine in which putrefaction had already been set up by inoculation, it was found that a 5% solution so modified the conditions that the putrescence ceased, and a 2½% solution inhibited the development of bacteria, so that the liquefaction of the gelatine was practically stopped. Other experiments showed that in an atmosphere impregnated with ammonium carbonate meat could be kept for six months, and at the end of that time remain nearly unaltered.

The two cuts, Plates 19 and 20, represent two different arrangements of our pipe-coils—the one as applied to the chilling of beeves, the other arranged in a separate chamber overhead for the chilling of hogs. Where we can command the room, we prefer the second plan. It affords an excellent circulation of air, and keeps the room free from mist when the hot meat goes into it.

We are always prepared to furnish any information desired by parties contemplating artificial refrigeration, also plans or sketches of abattoirs free of charge, and we solicit correspondence on the subject.

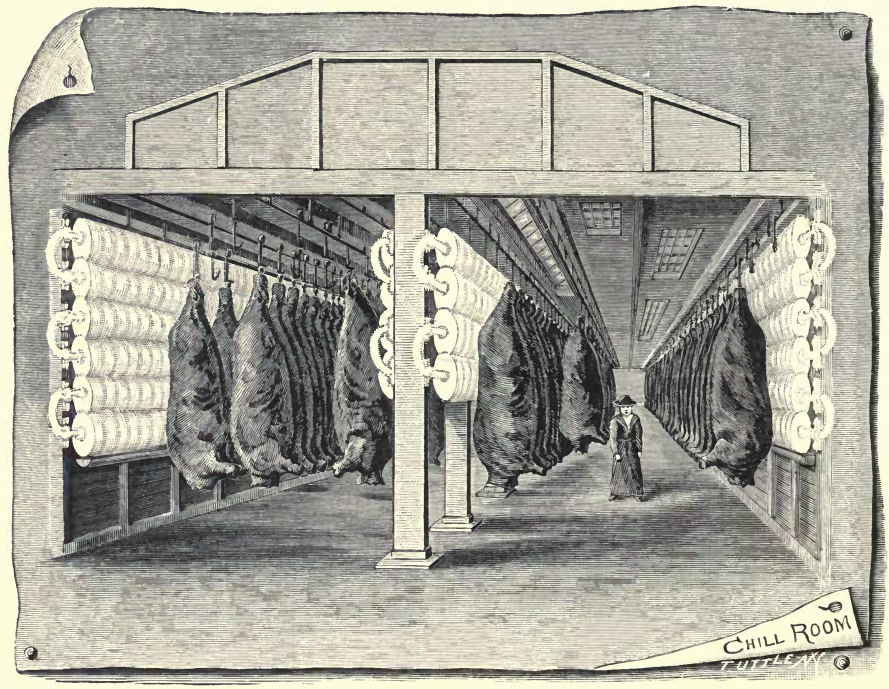



PLATE 19.—Beef Chill Room.

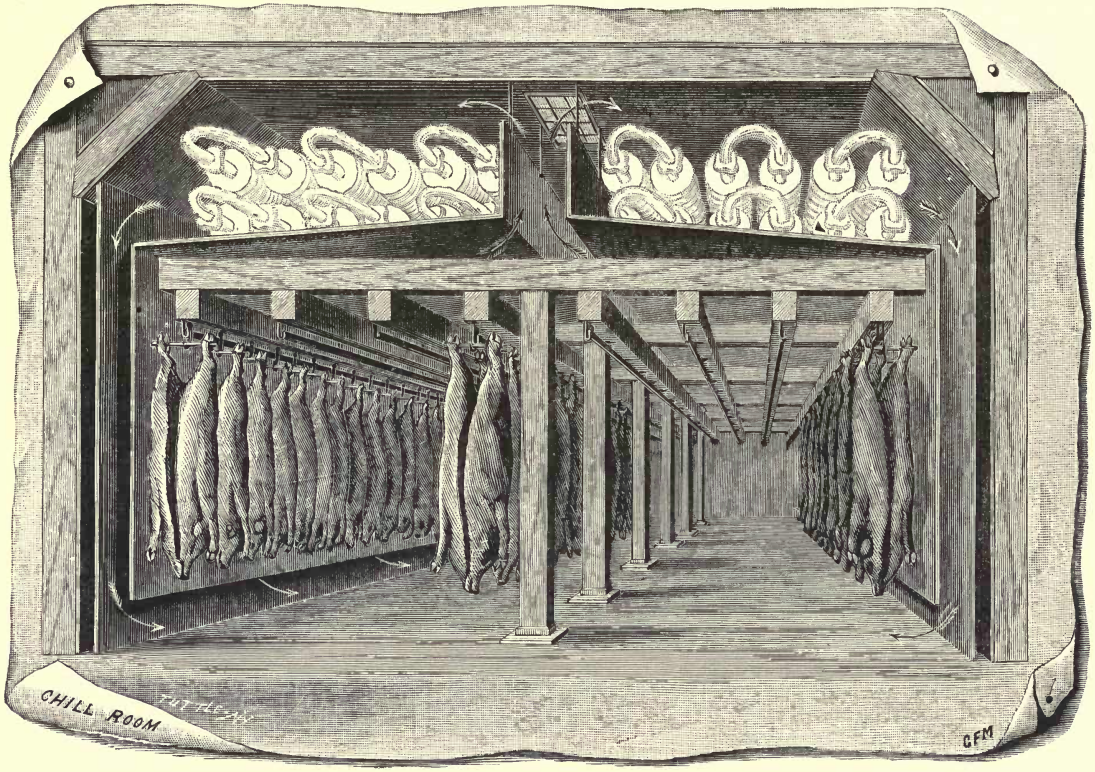



PLATE 20.—Hog Chill Room.

# THE MANUFACTURE OF ICE.

On the first pages of this catalogue we gave a brief sketch of the different inventions made in the first half of this century, the purpose of which was the artificial production of ice. After Twining's first success, in 1855, very little progress was made for many years. European machines, especially Carré's absorption machine, were brought into New Orleans about ten years later, and it was twenty years after Twining when the ammonia compression machines of the present day were introduced into our industries for the purpose of ice-making, as well as for the refrigeration of breweries.

To the great success of the brewing industry in the United States is due the rapid introduction of the ammonia compression machines for purposes of air-cooling. Here was a field which offered great temptations for improvements, and the result was the perfection of the gas-compressor with all its other appurtenances for the economical and reliable handling of the gas. This part of the apparatus having once obtained a high degree of utility, and having found a regular market in establishments requiring cold rooms, the next step forward was the application of the ammonia compressor to the purpose of ice-making.

During the last three decades almost innumerable patents have been taken out, all of which had in view improvements in the mode of freezing water for the

market. One great drawback to making clear, transparent ice was, right in the beginning, found to be the air, which all water of nature contains in solution. As soon as such water begins to freeze it eliminates the air in the shape of minute bubbles. If the process of freezing is rapid, these small bubbles are trapped in the ice forming, thus rendering the latter opaque. While thereby the purity of the ice is not impared, still its appearance makes it unsalable, and it melts considerably faster than the transparent article. If the freezing takes place at a temperature above twenty-four degrees the ice is perfectly clear on the outside, but the centre of a block thus frozen contains a large porous core, in which nearly all the air of the water which it held before freezing accumulates.

Many attempts at improvements in the freezing process of water have had for their object the making of transparent ice, others have aimed at shortening the time of freezing, but on the whole it may be asserted that the progress made cannot be compared to that which has attended the improvements in the gas-compressing and evaporating process, and much may yet be accomplished in that line.

## DIFFERENT SYSTEMS OF ICE-MAKING.

In the applications of a machine for making ice it seems that this art may aptly be divided into two grand systems, the one using brine for the purpose of freezing

water, the other effecting the freezing by direct expansion ; the same as in refrigerating plants.

It is clear, that it avoids a great deal of superfluous apparatus, of loss in efficiency, and of untidiness, if the cooling or freezing is done directly without the interpolation of brine. Experimenters have for this reason tried to do away with brine in ice-making, as it has been abolished in the refrigeration of rooms. But here much greater obstacles have been met than in cooling-plants. Given a good pipe-system, and refrigeration by direct expansion has no difficulties whatsoever. Where, however, water has to be solidified, the first drawback met is the necessity of straight surfaces. A wrought-iron pipe of no excessive diameter is the safest and cheapest means of confining ammoniacal gas, but if ice is formed around pipes it becomes a matter of great wastefulness and trouble to loosen it again from the pipes. Straight surfaces are very difficult to construct and to keep tight, and all attempts to do this have been failures so far. Another proposition to freeze water without the use of brine has been to imitate nature, viz., to produce temperatures below the freezing-point in well-insulated rooms. But here the low specific heat of air and its low degree of conductibility proved such a great obstacle that the cooling surfaces of the rooms had to be made excessively large, and still the result was extremely slow freezing. Still another form of ice-machine is one which freezes the water *in vacuo* without the use of either brine or any other agent than the water itself. If water is exposed to an almost absolute vacuum it turns rapidly

into vapor, the transformation requiring so much heat, which is furnished by the water itself, that the balance of the water which is not vaporized freezes solid. The ice thus formed, however, is totally unfit for the market, being in the shape of granulated snow, full of air, brittle, and of no durability. This process was first proposed and introduced for the freezing of carafes by E. Carré (not the inventor of the absorption-machine), and afterwards carried out on a large scale by F. Windhausen in Germany in his vacuum ice-machine. The system, however, was not a successful one, partly on account of the poor quality of the ice, partly because the sulphuric acid, which was used as an auxiliary to the air-pump to carry away the aqueous vapor by absorption, caused great trouble in its process of recondensation.

The small success which attended all the attempts at ice-making without brine brought inventors back to the use of brine, and the different processes of to-day all use this otherwise undesirable commodity.

In its application the system of making ice by the use of brine is quite varied, but on the whole three different modes have, up to this day, established themselves in the market.

*First.* The system of removable cans.

*Second.* The plate system.

*Third.* The system of stationary cells.

The first is the one most in use the world over. In an iron or wooden tank, well insulated, a salt-brine is kept at a temperature considerably below the freezing point of water by evaporating-coils, which are connect-

ed to the gas pump, if the machine is a compression machine, or to the absorber if the machine is an absorption machine. In the brine galvanized iron cans are immersed. They contain the water to be frozen, and it is evident that in the course of time a coating of ice will form on the bottom and on the sides of the cans, and that after sufficient time has elapsed a solid block of ice will thus be produced in each can. One can after another is now lifted out of the brine—or freezing-tank, dipped into or sprinkled with tepid water, whereby the ice is loosened from the can and the block slipped out, the can again filled with fresh water and replaced in its position in the tank, where the freezing is again taken up. Thus a continuous process is established, which permits of a regular output throughout the day and night.

In the plate-system, which as a rule produces ice in pieces weighing one or more tons, a hollow plate of boiler-iron is formed and immersed in a tank containing fresh water to be frozen. This plate is filled with brine, which is kept below the freezing-point by evaporating-coils in a manner similar to those of the can-system. The coils may be either in the plates or outside in a separate brine tank, and the brine circulated through the plate. By thus keeping the plate at a sufficiently low temperature, ice will form on both sides of it, and by and by two layers of ice will be built up on the two sides of the plate. In order to remove this ice, the cold brine is drawn from the plates, and in case the evaporating-coils are inside of the plates the circulation of ammonia in them is stopped. Now tepid brine is supplied to the

hollow plates and after a short while the ice is loosened from them and can be hoisted out of the tank by means of cranes, and cut up into blocks of any desired size. A number of plates are, as a rule, immersed in each tank and a whole tank emptied at one time. In order to make the process continuous, more than one tank must be supplied, so that one at least is in continuous operation, while the other is being emptied and refilled and prepared again for work. But on larger plants even more than two tanks are necessary to permit of a daily drawing of ice. The freezing process going on from one side only, *i. e.*, a certain thickness of ice being formed by building up only on one side, the time of freezing is necessarily long. In a can, ice is formed on two opposite sides, and the two surfaces, growing together in the centre, will ultimately make a solid block equal in thickness to the width of the can. If ice of such thickness is made on a plate frozen only from one side, it takes about four times as long. Nevertheless, the plate system has certain advantages, to which we will recur later on.

In the system using stationary cells the cold brine is pumped through the hollow walls of the cells, the latter being open at the top and filled nearly brimful with the fresh water to be frozen. Ice will form in the cells the same as in the can system. After the blocks are finished in the cells, tepid brine is pumped in place of the cold brine, and thereby the ice loosened from the cells, and its removal becomes a matter of little time. It is self-evident that in this system a whole tank has to be emptied at the same time, as in the plate system, and to

make the plant continuous in its operation, more than one tank has to be employed. If the cells are made quite deep in proportion to their width, similar to the cans used in the can system, then of course the freezing time is as fast as in the system first described. But if shallow cells, pan-shape, are used, the depth being small in proportion to length and width, then the freezing will practically be done mostly from the bottom, and for the same thickness of ice the time of freezing will be quadrupled as in the plate system. There is an object in using either the deep or the shallow cell, as will be shown later on.

*Transparent Ice.*—In the beginning of the industry of ice-making, many manufacturers were satisfied with producing an article regardless of quality. Therefore no special pains were taken to make transparent ice, but by and by the demands for a better product were made. At first, freezing at comparatively high temperatures was resorted to, by which at least one part of the block becomes clear. But then the time of freezing was so slow, and it took a large number of cans and large tanks, and the first cost of the plant came to be high, and therefore means were tried to make the ice faster, freezing it at lower temperatures, and still making it clear.

Quite a number of inventions were made to obtain this object, all of which were more or less successful. One thing was soon discovered: that clear ice could be produced by agitating the water during the process of freezing, and the different propositions to accomplish this are quite numerous. A metal bar was let into the

can and lifted up and down by a small revolving shaft and thumb, or a crank; or a wooden paddle was inserted into the can and moved to and fro by some kind of mechanism; or a small perforated pipe was introduced into the can within a few inches from the bottom and a current of cold air forced through the pipe, rising in bubbles through the water and emerging at the top, thereby producing a circulation in the can. All of these arrangements had the disadvantage that, at the end of the operation of making the ice-block, the bar, paddle, or pipe had to be removed to prevent being frozen into the ice, while otherwise the effect was good. Another proposition was to rock the can in the tank, thus agitating the water. None of these different arrangements, however, found favor in practical use. The moving gear for many hundreds, even thousands, of cans proved quite cumbersome. In removing the cans from the tank, this gear was in the way, and had likewise to be removed, and on the whole few, and comparatively small, plants have adopted either one system.

The plate system and the shallow stationary cells alone avoided the agitation of the water, and yet produced clear ice. But the freezing taking place only from one side, the process was so slow and the plants became so large and expensive, that these systems also have found few users.

Another mode of making transparent ice is to deprive the water of its air before it goes into the cans. This can be done by long-continued boiling, or by exposing the water to a high vacuum; but better still by

distillation under exclusion of the atmosphere. The result of this process has been found extremely satisfactory, and is to-day the one most in use. In order to economize in fuel, however, it has been found necessary to use the exhaust steam from the engine for the purpose of ice-making, and the steam therefore had to be deprived of the oil used in lubricating the steam cylinder. This has effectually been accomplished by steam-filters of very simple construction. After condensation of the steam thus filtered, the condensed water is again filtered in order to entirely deodorize it. As a result can-ice produced in this manner is as good as ice can be made. It contains but a very thin stratum of porous ice in the centre, due to reabsorption of air in the can during freezing, but it is better and purer, and more durable than any natural ice which can be bought. The ice is obtained in rectangular blocks of any desired size, and the waste by melting the ice of the moulds reduced to a minimum.

The constantly increasing demand for "hygienic" ice brings the necessity of artificial ice more and more in the foreground, and this circumstance, together with the fact that such ice can be produced economically, has resulted in the great impetus which the establishing of ice-factories is now receiving. The constantly increasing contamination of the water sources in the neighborhood of large cities, from which ice is harvested, brings with it great dangers to the health of the communities, and the sanitary boards of cities and health-resorts have of late given the question of ice consumption considerable attention.

# DESCRIPTION OF THE DE LA VERGNE ICE-MAKING PLANT.

In the appended woodcut, Plate 21, the arrangement of our ice-making plant is shown, the whole spread out on one sheet to facilitate following the circulation of the ammonia, the oil, the steam, etc., without being compelled to refer to different views, whereby the layman is easily misled. It will be understood that the different parts may be placed in relatively different positions to each other as long as the principle of the system is not thereby disturbed.

Let us first follow the circulation of the ammonia through the system and learn how the cold is produced which ultimately freezes the water:

We will begin at the compressor, which is shown to be a double-acting one and marked *A*. On the right-hand side the gas is drawn from the evaporating-coils through the suction pipe *B*. By the action of the compressor the gas is discharged through the pipe *C* into the pressure tank *D*, where the oil, which we will follow later on, is dropped to the bottom. The upper half of this tank is provided with cast-iron baffle-plates, which serve to more completely retain the oil and lodge it in the bottom. From the tank the gas, still hot by its compression, is sent through the pipe *E* into the bottom pipe of the condenser *F*, where, by the action of cold water

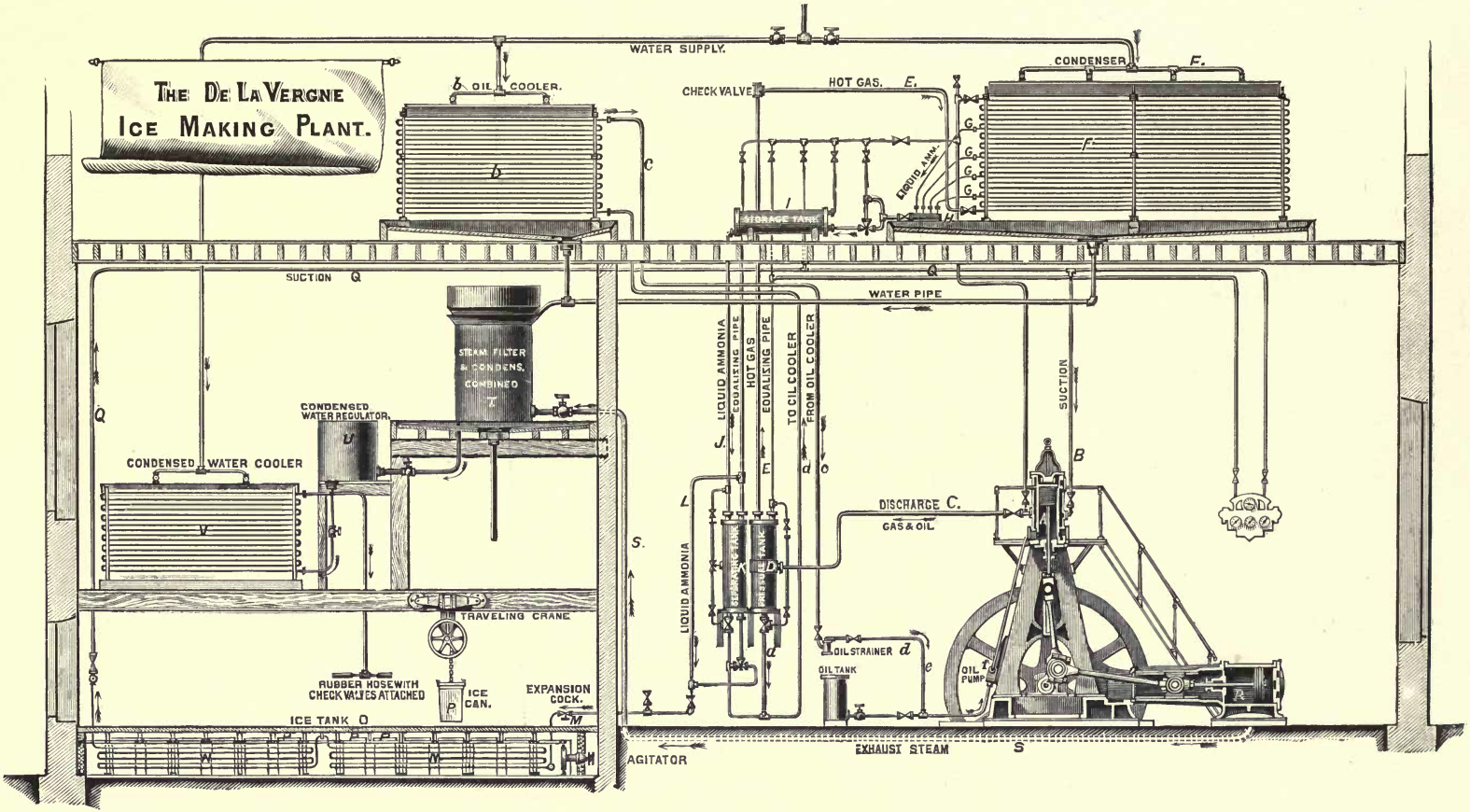



PLATE 21.—The De La Vergne Ice-Making Plant.

running over the pipes, the hot gas is first cooled and then liquefied. The small liquid pipes *G* conduct the liquid ammonia through the liquid leader *H* into the storage tank *I*, and from there is run through the pipe *J* into the bottom of the separating-tank *K*, which should be at all times at least three-fourths full. The small pipe *L* carries the liquid ammonia, in consequence of the pressure on it, to the expansion cock *M*, through which it is injected into the evaporating coils *N*, placed in the freezing tank *O*. This tank contains a salt brine noncongealable except at a temperature near zero, and by the absorption of heat from this brine the ammonia in vaporizing cools it down to a temperature below 32°, say 17° or 18°. Of the coils *N*, there are a number side by side, leaving space enough between them to insert the galvanized-iron ice-cans *P*, which contain the water to be frozen. After evaporating in the coils *N*, and thereby having taken up its quotum of heat from the brine, the ammonia gas now passes through the pipes *Q* and *B* back into the compressor from which we started. This is the entire cycle through which the ammonia passes.

In the description of our compressor on page 32 we mentioned our patented system of oil-circulation. This we will now take up.

We found that the oil heated with the gas by compression was dropped into the bottom of tank *D*. From there it passes through the pipe *a* to the lowest pipe of the oil-cooler *b*, similar in construction to the condenser, and, like it, cooled by cold water showered over it.

After being cooled down in the oil-cooler, it passes through pipe *c*, strainer *d*, and pipe *e* into the oil-pump *f*, which is so constructed that it distributes the cold oil into the compressor on either side of the piston during its compression stroke, *i. e.*, in such a manner that no oil is furnished during the suction stroke of the piston, but only during the time of compressing, thereby cooling the gas during its period of heating. The hot oil after leaving the compressor now returns again in company of the hot gas to tank *D*, and from there again enters on its course through the oil-cooler, strainer, and oil-pump to the compressor.

It will be seen that both the ammonia and oil go through complete cycles, and that no waste of either will occur except by leakage. In case, however, small traces of oil are carried along with the current of the gas from the pressure tank *D* into the condenser *F*, these small quantities flow along with the liquid ammonia into the separating tank *K*, where they collect at the bottom, the oil being heavier than liquid ammonia. When a certain amount of oil has collected here it can be drawn off through the cock *g* and pipe *h*, and carried through the oil-cooler back into the oil-pump and compressor.

The steam from the steam cylinder, marked *R*, passes through the exhaust pipe *S* into the steam-filter and condenser *T*, where it is purified and condensed. Out of condenser *T* it runs into the water regulator tank *U*, from there through the condensed water-cooling coil *V*, constructed like the ammonia condenser and oil cooler, and cooled by cold water, and is ultimately filled into

the ice-cans through rubber hose and cocks. After the cans have their contents frozen, the traveling-crane transports them to the dip-tank or sprinkler, where the block is melted out. The empty can is put back into its position in the freezing-tank, refilled with water, and the process of making another block is commenced.

# OTHER APPLICATIONS.

THE refrigerating machinery built by us is adapted to all purposes of cooling or ice-making, and can be employed not only by mammoth packing or brewing establishments, but by hospitals, steamships, theatres, hotels, markets, preserving-houses, and even private houses—in fact, in any place where ice or its equivalent has to be used for producing cold.

In reading over our list of customers, which is found in this book, it will be seen that we have lately furnished machines to chemical factories, and also to a number of hotels and restaurants. Confectioners, chocolate manufacturers, steamships, and wineries have their representatives in the list, and the field of application is constantly growing. The testimonial of the managers of the first hotel we fitted up is proof enough of the satisfaction it gives, and we feel confident that a call at the Murray Hill Hotel, in New York, by anyone directly interested in the management of a hotel or large club-house, cannot fail to convince him that mechanical refrigeration is a success for this class of establishments as well as for breweries and packing-houses.

To the eight original patents under which we commenced to build our machines a large number has been added by purchase, and we shall protect our rights in

them, and the rights of our customers to use them, whenever necessity arises.

In conclusion, permit us to call the attention of the reader to a fact which has, without question, been proven by the experience of manufacturers and users of machinery, that is, "that cheap machinery is dear at *any* price."

Too often the purchase-money is simply the first instalment paid, and the constantly accumulating expense for repairs, in many cases, exceeds in the aggregate, the first cost.

It would, indeed, be fortunate if this were the only disadvantage under which the purchaser of cheap machinery labors; but there is scarcely a person who has had extended experience with cheap machinery who will not testify to the additional fact that the loss occasioned by the imperfect working or the disarrangment of such machinery, to say nothing of aggravating and vexatious delays, is of vastly greater importance than the money wasted in the purchase and repairs of the inferior machinery.

There are none who can more fully appreciate the truthfulness of this declaration than those who have had the misfortune to own unsuccessful refrigerating plants.

In this particular line it is positively imperative that every part of the apparatus, even the smallest and apparently the most insignificant attachment, shall be made with the utmost skill and care.

Our experience in the construction of successful machinery, adapted for purposes of refrigeration, has ex-

tended over a period of eleven years, and we fully believe that such machinery cannot be too well or too carefully built. We regard the policy which encourages the construction of what is known as "cheap machinery," particularly for this purpose, as suicidal in the extreme, and one which will positively recoil upon the builder and destroy both his business and his reputation. For these reasons we have determined to build nothing but the best, and shall spare neither pains nor expense to accomplish the end we have in view, which is to supply our customers with a machine that is absolutely reliable at all times and under all conditions.

The first cost may be in excess of that of some machines in the market, but *our machines do the work required of them*, and not in a single instance has one of them failed to do all, and more than it was guaranteed to do, and to give satisfaction to its owner.

The true value of an investment is to be estimated by the satisfaction which it gives.

THE DE LA VERGNE REFRIGERATING MACHINE COMPANY,
Foot of East 138th Street, New York.

The sizes of machines for which we now have the patterns, and which may be ordered from us at any time, are the following:

MACHINES WITH SINGLE-ACTING COMPRESSORS.

| Compressors. | Steam Cylinders. | Horse-power required. | Capacity of Machines in Ice Melted every 24 hours. | Capacity of Machines in Ice Manufactured every 24 hours. |
|---|---|---|---|---|
| One 6 x 10 | One 7 x 10 | 3 H.-P. | 2 Tons. | 1 Ton. |
| Two 6 x 12 | " 9 x 12 | 6 " | 4 " | 2 Tons. |
| " 8 x 16 | " 12 x 16 | 13 " | 9 " | 5 " |
| " 9 x 16 | " 13 x 16 | 17 " | 12 " | 7 " |
| " 10 x 20 | " 16 x 20 | 25 " | 18 " | 10 " |
| " 12 x 24 | " 18 x 24 | 47 " | 35 " | 20 " |
| " 14 x 28 | " 22 x 28 | 66 " | 50 " | 30 " |
| " 16 x 32 | " 26 x 32 | 100 " | 75 " | 45 " |
| " 18 x 36 | " 32 x 36 | 140 " | 110 " | 65 " |

MACHINES WITH DOUBLE-ACTING COMPRESSORS.

| Compressors. | Steam Cylinders. | Horse-power required. | Capacity of Machines in Ice Melted every 24 hours. | Capacity of Machines in Ice Manufactured every 24 hours. |
|---|---|---|---|---|
| One 6 x 10 | One 9 x 10 | 6 H.-P. | 4 Tons. | 2 Tons. |
| Two 6 x 12 | " 12 x 12 | 12 " | 9 " | 5 " |
| " 8 x 16 | " 16 x 16 | 23 " | 18 " | 10 " |
| " 9 x 18 | " 18 x 18 | 31 " | 25 " | 15 " |
| " 10 x 20 | " 20 x 20 | 42 " | 35 " | 20 " |
| " 11 x 22 | " 22 x 22 | 60 " | 50 " | 30 " |
| " 12 x 24 | " 24 x 24 | 77 " | 65 " | 40 " |
| " 14 x 28 | " 28 x 28 | 119 " | 100 " | 60 " |
| " 16 x 32 | " 32 x 32 | 180 " | 150 " | 90 " |
| " 18 x 36 | " 36 x 36 | 250 " | 220 " | 130 " |

The above capacities are based on 40 revolutions per minute.

# LIST OF CUSTOMERS.

January 1, 1890.

# The De La Vergne Refrigerating Machine Co.,

**Foot of East 138th Street, NEW YORK CITY.**

## BREWERIES.

| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| Jacob Ruppert | New York | One | 110-ton | 110 tons..1884 |
| Jacob Ruppert—Second Order | New York | Two | 110 " | 220 " ..1885 |
| George Ehret | New York | One | 110 " | 110 " ..1885 |
| George Ehret—Second Order | New York | Two | 110 " | 220 " ..1885 |
| William J. Lemp | St. Louis, Mo | Two | 110 " | 220 " ..1888 |
| William J. Lemp—Second Order | St. Louis, Mo | One | 110 " | 110 " ..1889 |
| Bernheimer & Schmid | New York | One | 220 " | 220 " ..1888 |
| †Anheuser-Busch Brewing Ass'n | St. Louis, Mo | One | 110 " | 110 " ..1886 |
| Anheuser-Busch Brewing Ass'n—Second Order | Kansas City, Mo | One | 12 " | 12 " ..1886 |
| †Anheuser-Busch Brewing Ass'n—Third Order | St. Louis, Mo | One | 110 " | 110 " ..1189 |
| Anheuser-Busch Brewing Ass'n—Fourth Order | Dallas, Texas | One | 4 " | 4 " ..1889 |
| (For Fifth and Sixth orders from Anheuser-Busch Brewing Association, see Artificial Ice Plants.) | | | | |
| Budweiser Brewing Co., Lim'd | Brooklyn, N. Y | One | 110 " | 110 " ..1886 |
| *L. Schlather Brewing Co | Cleveland, Ohio | One | 110 " | 110 " ..1888 |
| Hinckel Brewing Co | Albany, N. Y | One | 100 " | 100 " ..1889 |
| Joseph Schlitz Brewing Co.—First Order | Memphis, Tenn | One | 4 " | 4 " ..1886 |
| Joseph Schlitz Brewing Co.—Second Order | Milwaukee, Wis | One | 100 " | 100 " ..1890 |
| Eberhardt & Ober Brewing Co | Pittsburgh, Pa. | One | 100 " | 100 " ..1890 |
| †Hyde Park Brewery Co | St. Louis, Mo | One | 75 " | 75 " ..1886 |
| †Pabst Brewing Co | Milwaukee, Wis | One | 75 " | 75 " ..1886 |
| *John Wieland Brewing Co | San Francisco, Cal. | One | 75 " | 75 " ..1889 |
| Falk, Jung & Borchert Brewing Co. | Milwaukee, Wis | One | 75 " | 75 " ..1889 |
| Ballantine & Co | Newark, N. J | One | 64 " | 64 " ..1882 |
| Ballantine & Co.—Second Order | Newark, N. J | One | 110 " | 110 " ..1886 |
| Ballantine & Co.—Third Order | Newark, N. J | Two | 100 " | 200 " ..1890 |
| †Bergner & Engel Brewing Co | Philadelphia, Pa | One | 50 " | 50 " ..1884 |
| †Bergner & Engel Brewing Co.—Second Order | Philadelphia, Pa | One | 50 " | 50 " ..1885 |
| †Bergner & Engel Brewing Co.—Third Order | Philadelphia, Pa | One | 110 " | 110 " ..1888 |
| †Bartholomay Brewing Co | Rochester, N. Y | One | 50 " | 50 " ..1886 |
| Bartholomay Brewing Co.—Second Order | Rochester, N. Y | Two | 50 " | 100 " ..1887 |

| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| Rochester Brewing Co. | Rochester, N. Y. | One | 50-ton. = 50 tons. | 1888 |
| Rochester Brewing Co. — Second Order | Rochester, N. Y. | One | 100 " = 100 " | 1889 |
| Z. Wainwright Brewing Co. | Pittsburgh, Pa. | Two | 65 " = 130 " | 1890 |
| Macon Brewing Co. | Macon, Ga. | Two | 65 " = 130 " | 1890 |
| S. Liebmann's Sons. | Brooklyn, N. Y. | Two | 50 " = 100 " | 1883 |
| Wainwright Brewery Co. | St. Louis, Mo. | Two | 50 " = 100 " | 1884 |
| Rubsam & Horrman. | Staten Island. | Two | 50 " = 100 " | 1885 |
| Conrad Stein. | New York. | Two | 50 " = 100 " | 1886 |
| Beadleston & Woerz. | New York. | Two | 50 " = 100 " | 1885 |
| *Jacob Hoffmann Brewing Co. | New York. | Two | 50 " = 100 " | 1887 |
| J. & P. Baltz Brewing Co. | Philadelphia, Pa. | Two | 50 " = 100 " | 1887 |
| Leonhard Eppig. | Brooklyn, N. Y. | Two | 50 " = 100 " | 1887 |
| Crescent City Brewing Co. | New Orleans, La. | Two | 50 " = 100 " | 1888 |
| Louis Bergdoll Brewing Co. | Philadelphia, Pa. | One | 64 " = 64 " | 1882 |
| Louis Bergdoll Brewing Co.—Second Order. | Philadelphia, Pa. | Two | 50 " = 100 " | 1885 |
| The Bartholomae & Leicht Brewing Co. | Chicago, Ill. | Two | 50 " = 100 " | 1889 |
| Otto Huber. | Brooklyn, N. Y. | Two | 35 " = 70 " | 1881 |
| Otto Huber—Second Order. | Brooklyn, N. Y. | One | 50 " = 50 " | 1885 |
| Gottfried Krueger. | Newark, N. J. | Two | 35 " = 70 " | 1883 |
| Gottfried Krueger—Second Order. | Newark, N. J. | One | 50 " = 50 " | 1885 |
| Burr, Son & Co. | New York. | Two | 35 " = 70 " | 1880 |
| Obermeyer & Liebmann. | Brooklyn, N. Y. | Two | 35 " = 70 " | 1884 |
| Peter Hauck & Co. | Newark, N. J. | Two | 35 " = 70 " | 1884 |
| Christian Schmidt. | Philadelphia, Pa. | Two | 35 " = 70 " | 1885 |
| †A. Finck & Son | New York. | Two | 35 " = 70 " | 1885 |
| Franz J. Kastner. | Newark, N. J. | Two | 35 " = 70 " | 1885 |
| Christian Weyand. | Buffalo, N. Y. | Two | 35 " = 70 " | 1886 |
| C. Trefz. | Newark, N. J. | Two | 35 " = 70 " | 1886 |
| J. H. Von der Horst & Son. | Baltimore, Md. | Two | 35 " = 70 " | 1886 |
| Monroe Eckstein. | Staten Island. | Two | 35 " = 70 " | 1887 |
| M. Groh's Sons. | New York | Two | 35 " = 70 " | 1887 |
| Weckerling Brewing Co. | New Orleans, La. | Two | 35 " = 70 " | 1888 |
| Pelican Brewing Co. | New Orleans, La. | Two | 35 " = 70 " | 1888 |
| Frederick Koehler & Co. | Erie, Pa. | Two | 35 " = 70 " | 1890 |
| Suffolk Brewing Co. | Boston, Mass. | One | 65 " = 65 " | 1890 |
| American Brewing Co. | Chicago, Ill. | One | 65 " = 65 " | 1890 |
| Northwestern Brewing Co. | Chicago, Ill. | One | 65 " = 65 " | 1890 |
| H. B. Scharmann | Brooklyn, N. Y. | One | 50 " = 50 " | 1883 |
| H. B. Scharmann—Second Order. | Brooklyn, N. Y. | One | 50 " = 50 " | 1888 |
| Claus Lipsius. | Brooklyn, N. Y. | One | 50 " = 50 " | 1883 |
| Claus Lipsius—Second Order | Brooklyn, N. Y. | One | 50 " = 50 " | 1885 |
| William Ulmer. | Brooklyn, N. Y. | One | 50 " = 50 " | 1886 |
| William Ulmer—Second Order. | Brooklyn, N. Y. | One | 50 " = 50 " | 1886 |
| H. & J. Paff. | Boston, Mass. | One | 50 " = 50 " | 1884 |
| H. & J. Paff—Second Order. | Boston, Mass. | One | 50 " = 50 " | 1885 |
| Henry Muller. | Philadelphia, Pa. | One | 50 " = 50 " | 1884 |
| Henry Muller—Second Order. | Philadelphia, Pa. | One | 50 " = 50 " | 1886 |
| Ph. Zang & Co. | Denver, Col. | One | 50 " = 50 " | 1886 |
| Ph. Zang & Co—Second Order. | Denver, Col. | One | 50 " = 50 " | 1887 |
| *Jos. Schnaider's Brewing Co. | St. Louis, Mo | One | 50 " = 50 " | 1886 |
| *Jos. Schnaider's Brewing Co.—Second Order. | St. Louis, Mo | One | 50 " = 50 | 1887 |
| *H. Grone Brewery Co. | St. Louis, Mo | One | 50 " = 50 | 1886 |
| *H. Grone Brewery Co.—Second Order. | St. Louis, Mo | One | 50 " = 50 " | 1888 |

| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| Jung Brewing Co. | Cincinnati, O. | One | 50-ton. = 50 tons | 1886 |
| Jung Brewing Co—Second Order. | Cincinnati, O. | One | 50 " " 50 " | 1886 |
| Christian Heurich. | Washington, D. C. | One | 50 " " 50 " | 1885 |
| John Roessle. | Boston, Mass. | One | 50 " " 50 " | 1885 |
| †H. Clausen & Son Brewing Co. | New York. | One | 50 " " 50 " | 1887 |
| B. Stroh Brewing Co. | Detroit, Mich. | One | 50 " " 50 " | 1887 |
| Fred. Miller Brewing Co. | Milwaukee, Wis. | One | 50 " " 50 " | 1887 |
| Fred. Miller Brewing Co.—Second Order. | Milwaukee, Wis. | One | 50 " " 50 " | 1889 |
| A. Griesedieck Brewing Co. | St. Louis, Mo. | One | 50 " " 50 " | 1888 |
| *Haffenreffer & Co. | Boston, Mass. | One | 50 " " 50 " | 1888 |
| Valentine Loewer | New York. | One | 50 " " 50 " | 1883 |
| Ziegele Brewing Co. | Buffalo, N. Y. | One | 50 " " 50 " | 1888 |
| National Brewing Co. | San Francisco, Cal. | One | 50 " " 50 " | 1889 |
| Jacob Ahles Brewing Co. | New York. | One | 50 " " 50 " | 1889 |
| Buffalo Brewing Co. | Sacramento, Cal. | One | 50 " " 50 " | 1889 |
| (For second order from Buffalo Brewing Co., see Artificial Ice Plants.) | | | | |
| William Peter. | Union Hill, N. J. | One | 50 " " 50 " | 1890 |
| D. M. Lyon & Sons | Newark, N. J. | One | 50 " " 50 " | 1890 |
| United States Brewing Co. | San Francisco, Cal. | One | 50 " " 50 " | 1890 |
| Peter Buckel. | New York. | One | 35 " " 35 " | 1889 |
| George Zett. | Syracuse, N. Y. | One | 35 " " 35 " | 1889 |
| Hubert Fischer | Hartford, Conn. | One | 35 " " 35 " | 1889 |
| Grasser & Brand Brewing Co. | Toledo, O. | One | 35 " " 35 " | 1889 |
| Ferd. Munch. | Brooklyn, N. Y. | One | 35 " " 35 " | 1882 |
| Ferd. Munch—Second Order. | Brooklyn, N. Y. | One | 35 " " 35 " | 1884 |
| Continental Brewing Co. | Philadelphia, Pa. | One | 35 " " 35 " | 1883 |
| Continental Brewing Co.—Second Order. | Philadelphia, Pa. | One | 35 " " 35 " | 1884 |
| C. Feigenspan. | Newark, N. J. | One | 35 " " 35 " | 1884 |
| C. Feigenspan—Second Order. | Newark, N. J. | One | 35 " " 35 " | 1886 |
| Wm. Hill. | Newark, N. J. | One | 35 " " 35 " | 1884 |
| Wm. Hill—Second Order | Newark, N. J. | One | 35 " " 35 " | 1886 |
| Chas. A. King. | Boston, Mass. | One | 35 " " 35 " | 1884 |
| J. Chr. G. Hupfel Brewing Co | New York. | One | 35 " " 35 " | 1886 |
| J. Chr. G. Hupfel Brewing Co.—Second Order. | New York. | One | 35 " " 35 " | 1887 |
| Ernst Bros. Brewing Co. | Chicago, Ill | One | 35 " " 35 " | 1886 |
| Ernst Bros. Brewing Co.—Second Order. | Chicago, Ill | One | 35 " " 35 " | 1887 |
| *A. Hupfel's Son. | New York. | One | 35 " " 35 " | 1886 |
| *A. Hupfel's Son—Second Order. | New York. | One | 35 " " 35 " | 1886 |
| George Guenther. | Baltimore, Md. | One | 35 " " 35 " | 1886 |
| Germania Brewing Co. | Syracuse, N. Y. | One | 35 " " 35 " | 1886 |
| W. G. Abbott Brewing Co. | Brooklyn, N. Y. | One | 35 " " 35 " | 1887 |
| N. Molter's Sons. | Providence R. I. | One | 35 " " 35 " | 1887 |
| †J. L. & W. L. Straus. | Baltimore, Md. | One | 35 " " 35 " | 1887 |
| J. L. & W. L. Straus—Second Order. | Baltimore, Md. | One | 65 " " 65 " | 1890 |
| Joseph Stoeckle. | Wilmington, Del. | One | 35 " " 35 " | 1888 |
| Welde & Thomas. | Philadelphia, Pa. | One | 35 " " 35 " | 1888 |
| San Antonio Brewing Co. | San Antonio, Tex. | One | 35 " " 35 " | 1888 |
| Jos. Fallert Brewing Co. | Brooklyn, N. Y. | One | 35 " " 35 " | 1888 |
| Jos. Fallert Brewing Co.—Second Order. | Brooklyn, N. Y. | One | 35 " " 35 " | 1889 |
| Katz Bros. | Paterson, N. J. | One | 35 " " 35 " | 1888 |
| M. Winter & Bros. | Pittsburgh, Pa. | One | 35 " " 35 " | 1889 |
| Burg & Pfaender. | Philadelphia, Pa. | One | 35 " " 35 " | 1889 |

UNIV. OF CALIFORNIA



| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| Miller Brewing Co | Rochester, N. Y | One | 35-ton. = 35 tons | 1887 |
| Miller Brewing Co.—Second Order. | Rochester, N. Y | One | 18 " " 18 " | 1888 |
| Leibinger & Qehm | Newtown, N. Y | One | 35 " " 35 " | 1889 |
| John Schuesler Brewing Co. | Buffalo, N. Y | One | 35 " " 35 " | 1889 |
| Schaefer & Meyer Brewing Co | Louisville, Ky | One | 35 " " 35 " | 1889 |
| Hellmann & Kipp | Waterbury, Conn | One | 35 " " 35 " | 1889 |
| Cincinnati Brewing Co | Hamilton, O | One | 35 " " 35 " | 1889 |
| Cincinnati Brewing Co. — Second Order | Hamilton, O | One | 65 " " 65 " | 1890 |
| *Oppmann Brewing Co | Cleveland, O | One | 35 " " 35 " | 1889 |
| Schmidt & Bro | Cincinnati, O | One | 35 " " 35 " | 1889 |
| Union Brewing Co | Rochester, N. Y | One | 35 " " 35 " | 1890 |
| Claussen-Sweeney Brewing Co | Seattle, W. T | One | 35 " " 35 " | 1890 |
| Kalmbach & Geisel | Springfield, Mass | One | 18 " " 18 " | 1887 |
| William Smith & Co | Boston, Mass | One | 18 " " 18 " | 1887 |
| Liebert & Obert | Manayunk, Pa | One | 18 " " 18 " | 1888 |
| Ph. Schneider Brewing Co | Trinidad, Col | One | 18 " " 18 " | 1888 |
| Joseph Weibel | New Haven, Conn | One | 18 " " 18 " | 1888 |
| Joseph Kohnle | Philadelphia, Pa | One | 12 " " 12 " | 1887 |
| Willibald Kuebler | Easton, Pa | One | 12 " " 12 " | 1887 |
| *Guayaquil Lager Beer Brewery Ass'n | Guayaquil, Ecuad | One | 12 " " 12 " | 1887 |
| Loebs Bros | Rochester, N. Y | One | 12 " " 12 " | 1888 |
| Loebs Bros. (American Brewing Co.)—Second Order | Rochester, N. Y | One | 65 " " 65 " | 1890 |
| H. Weidemann Brewing Co | New Haven, Conn | One | 12 " " 12 " | 1889 |
| Theo. R. Helb | York, Pa | One | 9 " " 9 " | 1885 |
| Eckart Bros | Bridgeport, Conn | One | 9 " " 9 " | 1885 |
| Eckart Bros.—Second Order | Bridgeport, Conn | One | 9 " " 9 " | 1886 |
| Herrall & Zimmerman | Portland, Ore | One | 9 " " 9 " | 1885 |
| G. Mander | Elmira, N. Y | One | 9 " " 9 " | 1889 |
| Theo. Finkenauer | Philadelphia, Pa | One | 9 " " 9 " | 1887 |
| Theo. Finkenauer—Second Order | Philadelphia, Pa | One | 18 " " 18 " | 1889 |

## ABATTOIRS AND PACKING-HOUSES.

| | | | | |
|---|---|---|---|---|
| *T. C. Eastman | New York | Two | 110-ton. = 220 tons | 1884 |
| W. H. Silberhorn | Sioux City, Ia | Two | 50 " " 100 " | 1887 |
| Nelson New River Platte Meat Co. | Zaratte, Argentine Republic | One | 65 " " 65 " | 1890 |
| Argentine Meat Co., Limited | Colon, Argentine Republic | One | 65 " " 65 " | 1890 |
| G. Sansinena & Co | Buenos Ayres, Argentine Republic | One | 65 " " 65 " | 1890 |
| St. Louis Beef Canning Co | E. St. Louis, Ill | One | 64 " " 64 " | 1882 |
| East Side Hide Association | New York | One | 50 " " 50 " | 1889 |
| Ryan Brothers | Cincinnati, O | One | 35 " " 35 " | 1887 |
| Rohe & Bro | New York | One | 35 " " 35 " | 1884 |
| *Rohe & Bro.—Second Order | New York | One | 9 " " 9 " | 1886 |
| Rohe & Bro.—Third Order | New York | One | 35 " " 35 " | 1888 |
| *Richard Webber | New York | One | 35 " " 35 " | 1888 |
| A. Sander & Co | Cincinnati, O | One | 18 " " 18 " | 1886 |
| Hart & Brother | Wilmington, Del | One | 18 " " 18 " | 1886 |
| Burkhardt Packing Co | Denver, Col | One | 18 " " 18 " | 1888 |
| Arnold Bros | Chicago, Ill | One | 18 " " 18 " | 1889 |
| Arnold Bros.—Second Order | Chicago, Ill | One | 18 " " 18 " | 1889 |
| Griffin & McElroy | Bridgeport, Conn | One | 18 " " 18 " | 1889 |
| Gebhardt W. Zeiger | Chicago, Ill | One | 12 " " 12 " | 1889 |
| Wm. Ottmann & Co | New York | One | 18 " " 18 " | 1890 |
| R. D. Waddell | Glasgow, Scotland | One | 4 " " 4 " | 1890 |

## COLD STORAGE.

| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| *Quaker City Cold Storage and Warehouse Co. | Philadelphia, Pa. | Two 65-ton.. | =130 tons.. | 1890 |
| Purfleet Wharf | London, Eng. | Two 40 " .. | 80 " .. | 1888 |
| Leadenhall Market | London, Eng. | One 35 " .. | 35 " .. | 1888 |
| *Washington Market Co. | Washington, D. C. | One 35 " .. | 35 " .. | 1888 |
| Spiers & Pond | London, Eng. | One 4 " .. | 4 " .. | 1888 |
| Fred Hollender & Co. | New York. | One 4 " .. | 4 " .. | 1888 |

## HOTELS AND RESTAURANTS.

| | | | | |
|---|---|---|---|---|
| *Murray Hill Hotel | New York. | One 9-ton .. | =9 tons.. | 1886 |
| *Plaza Hotel | New York. | One 9 " .. | 9 " .. | 1890 |
| *Portland Hotel Co. | Portland, Ore. | One 4 " .. | 4 " .. | 1890 |
| Hotel Luehrmann | Memphis, Tenn. | One 2 " .. | 2 " .. | 1889 |
| †Geo. D. Smith (Dairy Kitchen) | New York. | One 2 " .. | 2 " .. | 1888 |

## CHEMICAL WORKS.

| | | | | |
|---|---|---|---|---|
| St. Louis Ammonia and Chem. Co. | Cincinnati, O. | One 18-ton .. | =18 tons.. | 1886 |
| Baugh & Sons Co. | Philadelphia, Pa. | One 12 " .. | 12 " .. | 1887 |
| M. A. Seed Dry Plate Co. | St. Louis, Mo. | One 9 " .. | 9 " .. | 1887 |
| M. A. Seed Dry Plate Co.—Second Order. | St. Louis, Mo. | One 9 " .. | 9 " .. | 1890 |

## CONFECTIONERS AND CHOCOLATE MFRS.

| | | | | |
|---|---|---|---|---|
| Gousset & Eller | New York | One 4-ton.. | =4 tons .. | 1888 |
| Croft & Allen | Philadelphia, Pa. | One 4 " .. | 4 " .. | 1889 |
| Runkel Bros. | New York | One 4 " .. | 4 " .. | 1889 |

## STEAMSHIPS.

| | | | | |
|---|---|---|---|---|
| *Oceanic Steamship Co. | Str. *Australia* | One 2-ton.. | =2 tons .. | 1889 |

## WINERIES,

| | | | | |
|---|---|---|---|---|
| American Champagne Co. | San Francisco, Cal. | One 9-ton.. | =9 tons .. | 1889 |

## ARTIFICIAL ICE PLANTS.

| Name. | Address. | Number of Machines. | Total Ice-Making. | Year of Completion. |
|---|---|---|---|---|
| Bohlen-Huse Machine and Lake Ice Co. | Memphis, Tenn. | One 50-ton.. | =30 tons.. | 1887 |
| Bohlen-Huse Machine and Lake Ice Co.—Second Order. | Memphis, Tenn. | One 50 " .. | 30 " .. | 1889 |
| Buffalo Brewing Co.—Second Order. | Sacramento, Cal | One 50 " .. | 30 " .. | 1890 |
| John R. Tendick | San Antonio, Tex. | One 35 " .. | 20 " .. | |
| Count Albini | Rome, Italy | One 18 " .. | 10 " .. | 1887 |
| Anheuser-Busch Brewing Ass'n—Fifth Order. | Sherman, Tex. | One 18 " .. | 10 " .. | 1889 |
| Anheuser-Busch Brewing Ass'n—Sixth Order. | St. Louis, Mo. | One 220 " .. | 130 " .. | 1889 |
| E. M. Barretto | Manila, Philippine Islands | One 9 " .. | 5 " .. | 1885 |
| E. M. Barretto.—Second Order. | Manila, Philippine Islands | One 9 " .. | 5 " .. | 1886 |
| West Indian Ice and Refrigerating Co., Limited | Port of Spain, Trinidad Island, B. A. I | One 9 " .. | 5 " .. | 1885 |
| J. L. Millsbaugh | Fort Concho, Tex. | One 4 " .. | 2 " .. | 1884 |
| Edgar Fennell | Newport, Eng. | One 2 " . | 1 " .. | 1890 |

**252 Machines, equivalent in Tons of Ice melted each day, 11,277.**

* Brine plants.
† Partly brine and partly direct-expansion plants.
All others are direct-expansion plants.

# SUPPLEMENT.

## MACHINES SOLD FROM JAN. 1 TO APRIL 1, 1890.

### BREWERIES.

| Name. | Address. | Number of Machines. | Total Refrigeration. | Year of Completion. |
|---|---|---|---|---|
| The Christian Moerlein Brewing Co. | Cincinnati, O. | One | 100-ton. | =100 tons. 1890 |
| St. Louis Brewing Ass'n, Cherokee Brewery Branch | St. Louis, Mo. | One | 65 " | 65 " 1890 |
| Fred. Hower | Brooklyn, N. Y. | Two | 35 " | 70 " 1890 |
| Christian Moerlein and Wm. Gerst. | Nashville, Tenn. | One | 65 " | 65 " 1890 |
| Hinchliffe Bros. | Paterson, N. J. | One | 50 " | 50 " 1890 |
| George Brehm | Baltimore, Md. | One | 50 " | 50 " 1890 |
| Herman Straub & Co. | Pittsburgh, Pa. | One | 50 " | 50 " 1890 |
| The Grasser & Brand Brewing Co. —Second Order | Toledo, O. | One | 35 " | 35 " 1890 |
| M. Winter Bros. (second order). | Pittsburgh, Pa. | One | 65 " | 65 " 1890 |
| Oppman Brewing Co.—Second Order | Cleveland, O. | One | 65 " | 65 " 1890 |
| Edward Habich Norfolk Brewery. | Boston, Mass. | One | 35 " | 35 " 1890 |
| George V. Muth | Cleveland, O. | One | 35 " | 35 " 1890 |
| Indianapolis Brewing Co., P. Lieber Branch | Indianapolis, Ind. | One | 35 " | 35 " 1890 |
| George Hauck | Rondout, N. Y. | One | 18 " | 18 " 1890 |
| Selig Manilla | Springfield, Mass. | One | 18 " | 18 " 1890 |

### ABATTOIRS AND PACKING HOUSES.

| | | | | |
|---|---|---|---|---|
| T. M. Sinclair & Co. | Cedar Rapids, Ia. | Two | 100-ton. | =200 tons. 1890 |
| Joseph Stern | New York | One | 65 " | 65 " 1890 |
| Wm. H. Davis | Cincinnati, O. | One | 35 " | 35 " 1890 |
| Jeremiah Murphy | St. Louis, Mo. | One | 35 " | 35 " 1890 |
| Murray & Bro. | Rockaway B'ch, N. Y. | One | 2 " | 2 " 1890 |

### COLD STORAGE.

| | | | | |
|---|---|---|---|---|
| Otto Huber Brewery—Third Order. | Far Rockaway, N. Y. | One | 2-ton. | = 2 tons. 1890 |

### HOTELS AND RESTAURANTS.

| | | | | |
|---|---|---|---|---|
| Iroquois Hotel. | Buffalo, N. Y | One | 9-ton. | = 9 tons. 1890 |

### CONFECTIONERS AND CHOCOLATE MANUFACTURERS.

| | | | | |
|---|---|---|---|---|
| Fobes, Hayward & Co. | Boston, Mass. | One | 9-ton. | = 9 tons. 1890 |

### ARTIFICIAL ICE-PLANTS.

| | | | | Total Ice-Making. | |
|---|---|---|---|---|---|
| William J. Lemp.—Third Order. | St. Louis. Mo. | | Ice-Plant. | =120 tons. | 1890 |
| Corryville Artificial Ice Co. | Cincinnati, O. | One | 100-ton | 60 " | 1890 |
| A. Griesedieck Artificial Ice Co.— Second Order | St. Louis, Mo. | One | 100 " | 60 " | 1890 |
| Gottfried Krueger—Third Order. | Newark, N. J. | Two | 100 " | 120 " | 1890 |
| New York Hygeia Ice Co. (Limited.) | New York. | Two | 100 " | 120 " | 1890 |
| New York Steam Co. | New York. | One | 100 " | 60 " | 1890 |
| Otto Huber—Fourth Order. | Brooklyn, N. Y. | One | 65 " | 30 " | 1890 |
| Montgomery Brewing Co. | Montgomery, Ala. | One | 50 " | 30 " | 1899 |
| John R. Tendick | San Antonio, Tex. | One | 35 " | 20 " | 1890 |
| St. Louis Brewing Ass'n, Klausman Brewery Branch—Second Order | St. Louis, Mo. | | Ice-Plant. | 20 " | 1890 |
| St. Louis Brewing Ass'n, Schneider Brewery Branch—Third Order. | St. Louis, Mo. | | Ice-Plant. | 30 " | 1890 |
| P. Ballantine & Sons—Fourth Order | Newark, N. J. | | Ice-Plant. | 18 " | 1890 |
| Wm. Ottman. | New York. | | Ice-Plant. | 2 " | 1890 |
| Western Brewery Co. | Belleville, Ill. | | Ice-Plant. | 20 " | 1890 |

# Those Desiring an Estimate for the Cost of a Plant will Please Note the Following:

THE insulation and other conditions vary considerably in different establishments, therefore it is impossible to compile a price-list for our plants.

In justice to our customers, as well as to ourselves, we prefer to examine the buildings and ascertain the actual work to be done, and thus collect sufficient data to enable us to guarantee that a given amount of work will be satisfactorily performed, and from which to make careful estimates of the cost of erecting machines of ample capacity.

Upon application we will make a survey of premises, and submit plans and specifications, with an estimate of cost of the plant, free of charge.

Parties located at a distance desiring to know by mail the probable cost of a machine, will please supply us with the following information:

1st. The length, width, and height of the rooms or cellars to be refrigerated. If the cellars are arched, give us the height to the centre and to the spring of the arches.

2d. What you desire to refrigerate. Please state exactly.

3d. If a brewery, the number of barrels of wort to be cooled per day, and how rapidly you desire to cool it—that is, how many barrels per hour, and from what temperature down.

4th. If a packing-house or an abattoir, please state the number of carcasses to be cooled daily and their average weight.

5th. The temperature required in each room.

6th. The character, quantity, and temperature of the water at your disposal.

7th. Whether you desire to refrigerate by the direct expansion of the gas or by the circulation of brine.

8th. The annual consumption of ice heretofore.

Send a diagram of the establishment, that we may judge of the most economical plan of laying out the work, indicating upon it where you desire to locate your machine.

If you desire a plant for the manufacture of ice, state the number of tons of ice required as a daily production.

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